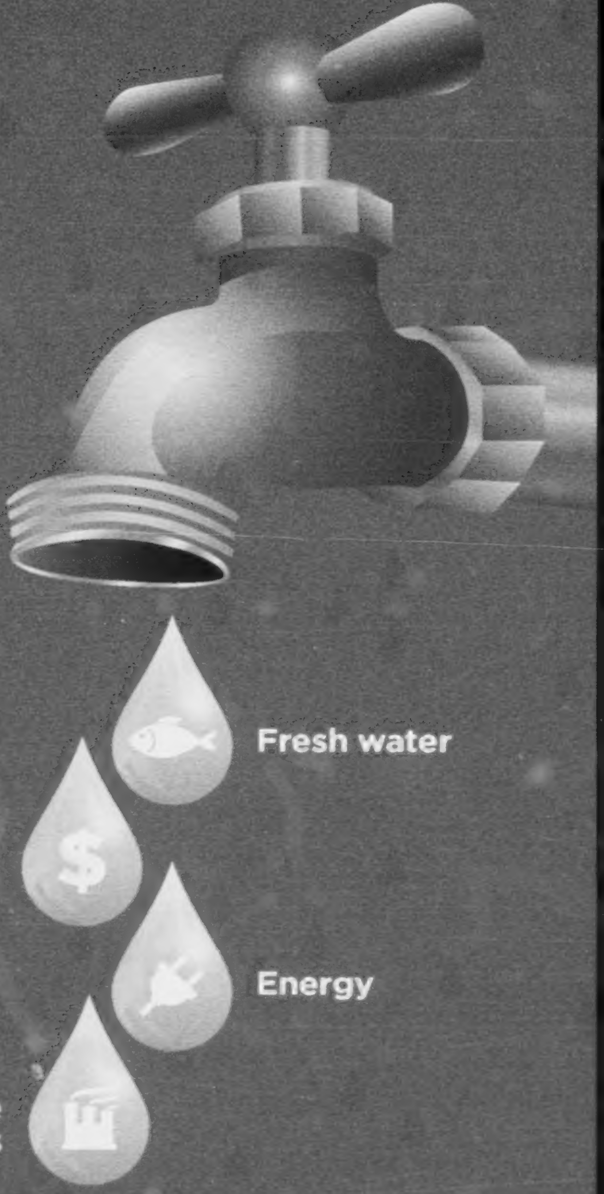
Every Drop Counts

Reducing the Energy and Climate Footprint of Ontario's Water Use



Environmental
Commissioner
of Ontario

Annual Energy Conservation Progress Report
2016/2017 (Volume One)

Thanks and Acknowledgments

The Environmental Commissioner would not have been able to produce this report without the invaluable assistance, input and feedback of many individuals and organizations, including those listed below.

However, this report represents the views of the ECO and does not imply endorsement from any other individual or organization.

Government Ministries, Agencies, Boards and Advisory Groups

Building Code Conservation Advisory Council, Independent Electricity System Operator, Ontario Clean Water Agency, Ontario Energy Board, Ontario Ministry of Agriculture, Food and Rural Affairs, Ontario Ministry of Energy, Ontario Ministry of the Environment and Climate Change, Ontario Ministry of Infrastructure, Ontario Ministry of Municipal Affairs, South Nation Conservation Authority, Toronto Atmospheric Fund, WaterTAP.

Municipalities and Municipal Organizations

Association of Municipalities of Ontario, Barrie, Clarington, Durham, Guelph, Hamilton, Lake Huron & Elgin Area Water Supply Systems, London, Oxford County, Peel, Toronto, Saint-Hyacinthe (Quebec), Utilities Kingston, York.

The ECO would also like to thank all the 110 Ontario municipalities who responded to our survey and follow-up questions. The survey questions and complete list of participating municipalities can be found in Appendix A.

Academic Institutions

University of Guelph (Plant Agriculture), Ryerson University (Research and Innovation Office), University of Toronto (Environmental Engineering and Energy Systems; Civil Engineering), University of Trent (Economics Department).

Industry, and Industry Associations

Anaergia, Canadian Biogas Association, Canadian Gas Association, Canadian Water and Wastewater Association, CH2M Hill, Enbridge Gas Distribution, Energy@Work, Gaz Métro, GE Water and Process Technologies, Greenfield Specialty Alcohols, Greyter Systems Inc., Hutchinson Environmental Sciences Ltd., Ontario Sewer and Watermain Construction Association, Residential and Civil Construction Alliance of Ontario, Riepma Consultants Inc., Southern Ontario Water Consortium, Union Gas.

Environmental
Commissioner
of Ontario

Commissaire à
l'environnement
de l'Ontario

May 2017

The Honourable Dave Levac
Speaker of the Legislative Assembly of Ontario

Room 180, Legislative Building
Legislative Assembly
Province of Ontario
Queen's Park

Dear Speaker,

In accordance with my mandate under section 58.1 of the *Environmental Bill of Rights, 1993*, I am pleased to present Volume One of the 2016/2017 Annual Energy Conservation Progress Report of the Environmental Commissioner of Ontario for your submission to the Legislative Assembly of Ontario.

The 2016/2017 Annual Energy Conservation Progress Report, my independent review of Ontario's progress in conserving energy, will be issued in two separate volumes. This first volume reviews the current energy and carbon footprint of Ontario's municipal water and wastewater systems, along with their impacts on freshwater sources and the financial costs of their energy use, and provides recommendations to the Ontario government to reduce these impacts. Volume Two of the report, to be issued later this year, will provide a broader review of progress of activities in Ontario in energy conservation.

Yours truly,

D Saxe

Dianne Saxe
Environmental Commissioner of Ontario

1075 Bay Street, Suite 605
Toronto, Canada M5S 2B1
E: commissioner@eco.on.ca
T: 416.325.3377
T: 1.800.701.6454
eco.on.ca

eco.on.ca

1075, rue Bay, bureau 605
Toronto, Canada M5S 2B1
E: commissioner@eco.on.ca
T: 416.325.3377
T: 1.800.701.6454
eco.on.ca

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Executive Summary

Energy, Greenhouse Gas Emissions, Fresh Water and Money (Chapter 1)

Most Ontarians take clean, cheap, safe, ample water for granted. This is particularly true for the 85% (about 11.6 million) who have unlimited clean water delivered to their taps by their municipal governments, and who can flush unlimited wastewater "away" into municipal pipes. Tap water is a much better energy and climate choice than bottled water – 40 to 1000 times better, in terms of fossil fuel use.

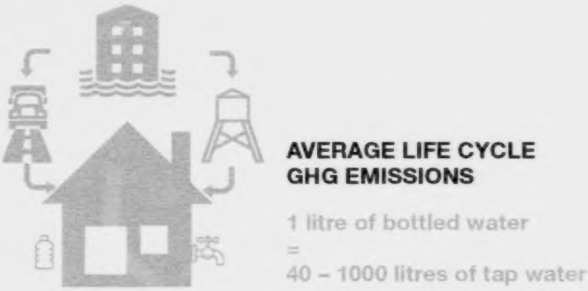

AVERAGE LIFE CYCLE GHG EMISSIONS
1 litre of bottled water
=
40 – 1000 litres of tap water

Figure 1.5. Greenhouse gas impact of tap water versus bottled water

But Ontario's **municipal water and wastewater systems have unnecessarily high energy use, greenhouse gas emissions, and fresh water demand.**

All levels of government are planning major investments in water infrastructure renewal in the coming years. This gives Ontario **a once-in-a-generation opportunity to cut energy costs and reduce the environmental footprint of municipal water and wastewater systems.**

Energy

Municipal water and wastewater systems are usually a municipal government's largest energy uses, consuming, on average, 38% of the energy. In 2011, water and wastewater systems used about 1,815 gigawatt-hours (GWh) of electricity (enough to power about 200,000 homes) and 40 million m^3 of natural gas (enough to heat approximately 15,000 homes). This energy use may rise, due to ever-more stringent treatment requirements, but these systems also have many opportunities to become more energy efficient, and even to generate renewable energy.

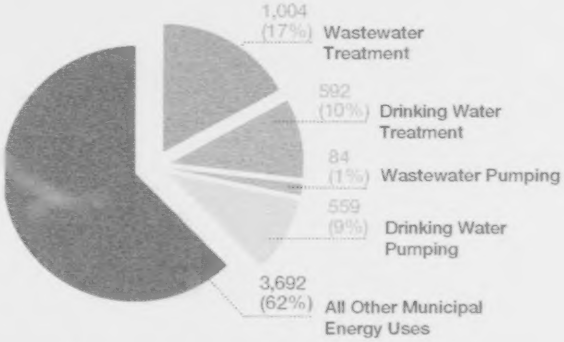


Figure 1.1. Ontario municipal energy consumption by facility type (eGWh), 2011

Note: "Other energy uses" include police stations, administrative buildings, community centres, and so on. It does not include municipal fleets or transit systems, for which energy use reporting is not yet required.

Source: O. Reg. 397/11, 2011 normalized data.

Greenhouse Gas Emissions

As shown in *Facing Climate Change*, the ECO's 2016 Greenhouse Gas Progress Report, Ontario urgently needs to reduce greenhouse gas (GHG) emissions and transition to a low-carbon economy. Municipal water and wastewater systems account for 32% of reported municipal GHG emissions; almost half of that comes from energy-intensive sewage treatment. The actual climate impact of these systems is even greater, because reported emissions only include GHGs from the energy that municipal systems purchase. Powerful GHGs from wastewater, such as methane, are not reported or are understated. These systems have many opportunities to reduce their direct and indirect GHG emissions.

Fresh Water

Water demand, land use development, and climate change are having significant impacts on Ontario's fresh water resources. Hotter, drier summers reduce the supply of water available to humans and to natural ecosystems precisely when municipal water demand peaks. Drought affected many Ontarians in 2016. Ontarians, especially those whose water does not come from the Great Lakes, can no longer assume they will always have as much water as they want whenever they want it. Better water conservation, and fewer leaks, could reduce the stress on our fresh water resources.

Money

Municipalities pay about $260 million dollars per year for the energy they use to operate water and wastewater systems. These costs are likely to rise, due to population growth, rising electricity rates, more energy-intensive treatment; and the ageing and historical underfunding of much existing infrastructure. Better energy and water efficiency could help keep costs down.

Energy Use in the Municipal Water Cycle (Chapter 2)

Municipal water and wastewater systems have opportunities to improve energy efficiency and reduce GHGs at all stages in the municipal water cycle:

- taking water from the natural environment;
- treating source water to meet drinking water regulatory requirements;
- delivering treated water to homes and businesses;
- collecting wastewater from homes and businesses; and
- treating wastewater to meet outflow requirements before discharge to the environment.

Municipal systems could save water, energy and money just by reducing leaks. They could also shift electricity demand away from peak periods, thus saving money and reducing GHGs.

Yet **municipal water and wastewater systems are energy efficiency laggards.** Their average electrical efficiency has improved only 1/10th as fast as the average Ontario customer, and reported leak rates are as high as 40%.

Why? Inadequate funding, data, incentives and attention have all played a part, plus a focus on short-term capital cost instead of lifecycle cost (including operating cost).

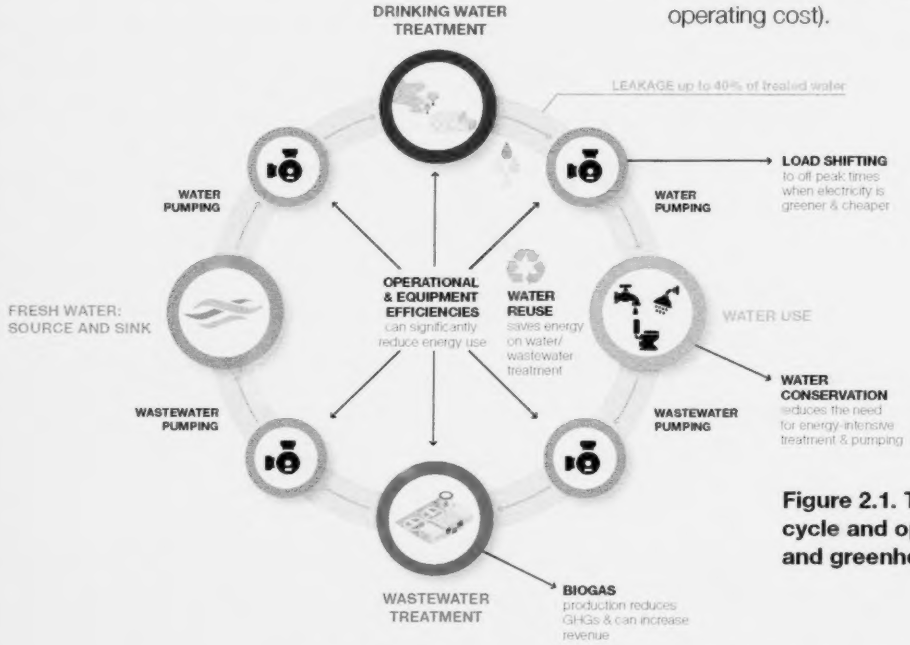

DRINKING WATER TREATMENT
LEAKAGE up to 40% of treated water
WATER PUMPING
WATER PUMPING
LOAD SHIFTING to off peak times when electricity is greener & cheaper
FRESH WATER: SOURCE AND SINK
OPERATIONAL & EQUIPMENT EFFICIENCIES can significantly reduce energy use
WATER REUSE saves energy on water/ wastewater treatment
WATER USE
WATER CONSERVATION reduces the need for energy-intensive treatment & pumping
WASTEWATER PUMPING
WASTEWATER PUMPING
WASTEWATER TREATMENT
BIOGAS production reduces GHGs & can increase revenue

Figure 2.1. The municipal water cycle and opportunities for efficiencies and greenhouse gas reductions

Making Energy Reporting Work (Chapter 3)

Energy reporting and benchmarking are important tools for enhancing conservation. However, Ontario's energy reporting regulation for the broader public sector – O. Reg. 397/11 under the *Green Energy Act*, – does not give municipal water and wastewater systems adequate information and benchmarks.

Why? First, O. Reg. 397/11 **reporting on water and wastewater systems unwisely leaves out much of what energy managers need to know**, including:

1. Energy used in pumping facilities; and
2. Renewable energy produced at water and wastewater pumping and treatment facilities, including energy captured from wastewater.

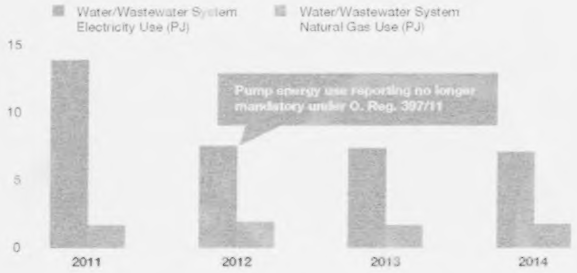


Figure 3.1. Reported provincial drinking water and sewage system energy use in petajoules (2011-2014)

Source: O. Reg. 397/11, raw data (2011-2014).

Second, O. Reg. 397/11 data are filed so late and are so poorly analyzed that they provide little value in benchmarking. Ontario should direct municipalities to submit their data via Portfolio Manager, which is online, free, and user-friendly. This tool can accept up-to-date utility data in electronic formats, and provide immediate analysis. It would help municipalities develop a meaningful energy and GHG baseline, benchmark against peers, identify savings opportunities, and monitor and verify results.

Third, the reporting system understates the climate damage of methane, by omitting methane emissions from wastewater and by underplaying the power of methane to contribute to climate change.

Can Asset Management Improve Energy Efficiency? (Chapter 4)

The provincial government now requires municipalities to have municipal asset management plans in order to receive infrastructure funding. These plans are supposed to help municipalities make "the best possible decisions regarding the building, operating, maintaining, renewing, replacing and disposing of infrastructure assets", i.e., to direct limited resources towards the most critical needs over the entire life cycle of all the municipality's infrastructure.

However, asset management planning needs adjustment to produce energy and environmental benefits for water and wastewater systems. Energy has a bigger impact on life-cycle costs for water and wastewater systems than for other municipal infrastructure. For these systems, asset management plans must:

- identify true life-cycle costs, including the long-term costs of operating water and wastewater infrastructure at acceptable service levels, including energy (and potentially greenhouse gas) costs; and
- trigger discussion on how to sustainably fund these costs.

By bringing long-term operating costs into all decisions on infrastructure design, construction, maintenance, repair and replacement, **asset management planning should motivate greater investment in energy efficiency.** It should also help provide adequate funding for such investments, by setting out an irrefutable case for higher water rates where appropriate.

In practice, asset management plans are of variable quality, are often based on inadequate data, and leave energy use out. Thus, Ontarians are rarely told the true cost of sustainable water and wastewater systems, and asset management planning does not yet drive better energy efficiency. Finding the funding for large efficiency projects remains difficult, even for projects that would quickly pay their way in energy savings.

The province is developing a new asset management regulation for municipalities. It should ensure that asset management plans incorporate long-term energy costs into all infrastructure decisions. It should also ensure that conserving water is considered before building new infrastructure.

Water Conservation (Chapter 5)

Ontario homes use a lot of water, averaging 200 litres per person per day, compared to 140 litres per person per day in water-efficient homes.

Municipalities save both money and energy when their water customers, such as households and businesses, use water efficiently. Individual water meters have reduced water waste, and could do the same in multi-unit buildings. Codes and standards for efficient products, in new and existing buildings, have done a lot to reduce indoor water use, and could do more.

Toilet	Faucet	Shower	Clothes washer	Leak	Bath	Other*	Dishwasher
24%	20%	20%	16%	13%	3%	3%	2%
123 L/day	**102 L/day**	**102 L/day**	**83 L/day**	**67 L/day**	**17 L/day**	**15 L/day**	**8 L/day**
TIP: Install water-efficient toilet (4.8 litres per flush or lower)	**TIP:** Install water-efficient faucets; Turn tap off while washing dishes, brushing teeth or shaving	**TIP:** Install water-efficient showerheads; Shorten showers; Reduce water temperature for energy savings	**TIP:** Choose water-efficient front-loading washer; Run with full loads; Use cold water setting for energy savings	**TIP:** Check whether water meter is running when no water is being used; test toilets for leaks using coloured dye	**TIP:** Reduce volume of bathwater; Reduce water temperature for energy savings	**TIP:** Use water-consuming appliances (e.g., humidifiers) only when needed	**TIP:** Run with full loads

*The "Other" category includes evaporative cooling, humidification, water softening, and other uncategorized indoor uses.

Figure 5.7: Indoor household water uses

Source: Water Research Foundation, *Residential End Uses of Water, Version 2*, 2016.

Note: Water use statistics based on a sample of approximately 1,000 single-family homes in 23 locations across the United States and Canada. Outdoor water use is not included.

Now **it is especially important to reduce outdoor water use,** e.g., lawn watering, which creates a large summer peak in municipal water demand. This peak demand is expensive to serve, and can be tough on aquatic ecosystems. It usually occurs at the same time as peak agricultural water demand, and when streamflow rates and soil moisture levels are at their lowest.

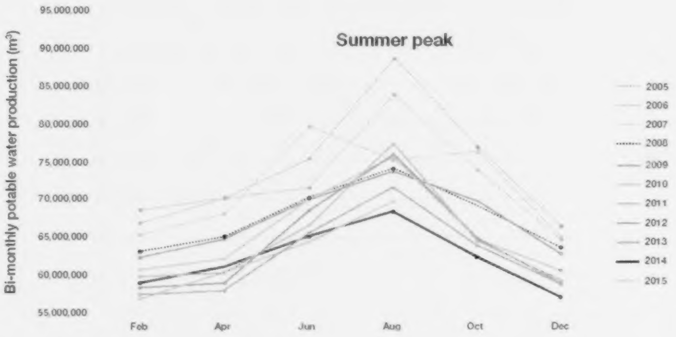


Figure 5.11: Toronto Water potable water production, 2005-2015

Source: City of Toronto

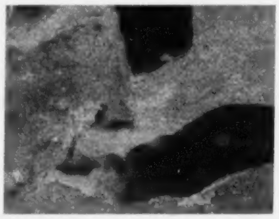
Water Reuse (Chapter 6)

Almost all water delivered by Ontario municipal water systems is treated to potable (drinking) standards, used only once, treated again as wastewater, and then discharged into surface waters. This once-through approach has substantial costs, in money, energy and GHGs, and can strain natural water sources. Yet little of the treated water is used for purposes that require potable water.

Many jurisdictions, including Israel, Singapore and California, have extensive programs to reuse partially or completely treated effluent from wastewater plants, but water reuse plays only a minor role in Ontario. Some Ontario municipalities are interested in water reuse, but are held back by the lack of clear provincial policies. In the long run, **Ontario municipalities could meet some non-potable water needs using treated wastewater effluent**, thus saving energy, money and GHG emissions, and relieving some seasonal water constraints. As part of its climate change adaptation plan, the province should set standards for water reuse.

Phosphorus (Chapter 7)

High nutrient levels (particularly phosphorus), climate change (intense rain events and rising temperatures) and land use changes are increasing toxic algal blooms in Ontario's lakes. The main sources of nutrients are agricultural and urban runoff ('non-point sources') and, to a much lesser extent, industrial and municipal wastewater ('point sources'). However, a key element of the province's response to the issue has been to require municipal wastewater facilities to reduce phosphorus effluent levels, in some cases to extremely low levels, significantly increasing capital and operating costs.



Lake Erie algal bloom, 2011.
Source: ESA Earth Online.

Meeting stringent phosphorus effluent standards at wastewater plants sometimes requires energy- and capital-intensive technology, which can be up to **five times more energy intensive** than the next highest treatment level. **Much larger reductions of phosphorus from non-point sources could be achieved and verified at a much lower cost** in energy, money and GHG emissions.

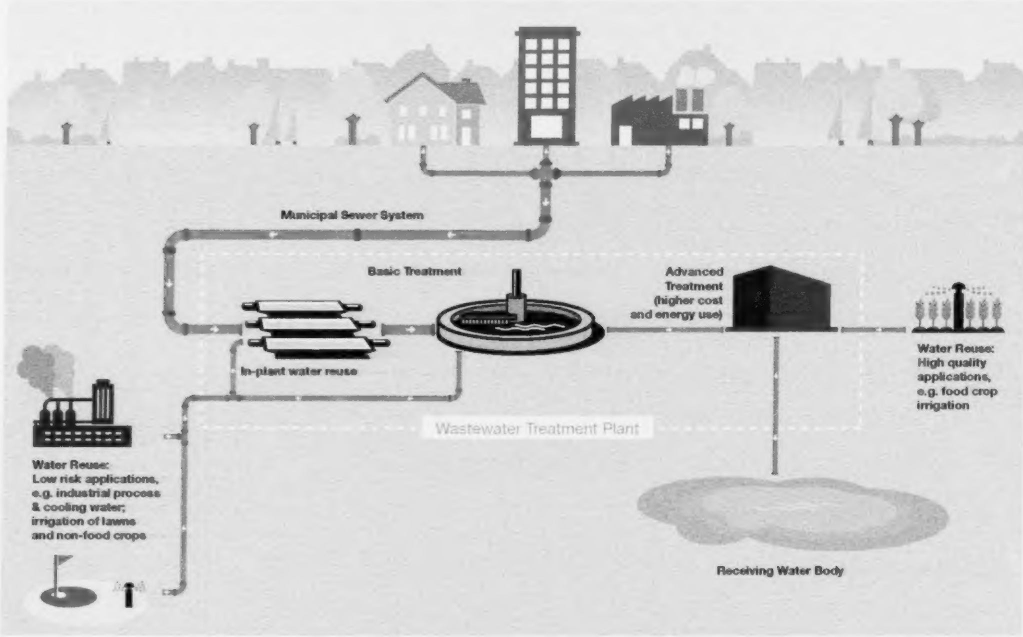

Municipal Sewer System
Basic Treatment
Advanced Treatment (higher cost and energy use)
In-plant water reuse
Wastewater Treatment Plant
Water Reuse: High quality applications, e.g. food crop irrigation
Water Reuse: Low risk applications, e.g. industrial process & cooling water; irrigation of lawns and non-food crops
Receiving Water Body

Figure 6.1. Centralized municipal water reuse

Energy from Sewage (Chapter 8)

Wastewater contains valuable energy that is now mostly wasted. Anaerobic digestion could capture much of that energy as methane (biogas) for on-site heating or combined heat and power; for vehicle fuel; or for injection into a gas utility as renewable natural gas.

Only a few Ontario wastewater plants use anaerobic digestion, and most of them flare (waste) at least some of the biogas. Wherever practical, **wastewater plants should become *renewable energy centres*** and generate biogas for productive use. This could be more cost-effective, and produce much more energy, if wastewater plants also digest concentrated organic wastes with the sewage, such as food waste, pet excrement, and/or agricultural residues. Co-digestion would also help keep organic wastes out of landfills, which is essential to Ontario's circular economy strategy, and would reduce landfill emissions of methane, a powerful GHG.

Bio-bus - showing where the fuel comes from

Source: Wessex Water/Julian James Photography.

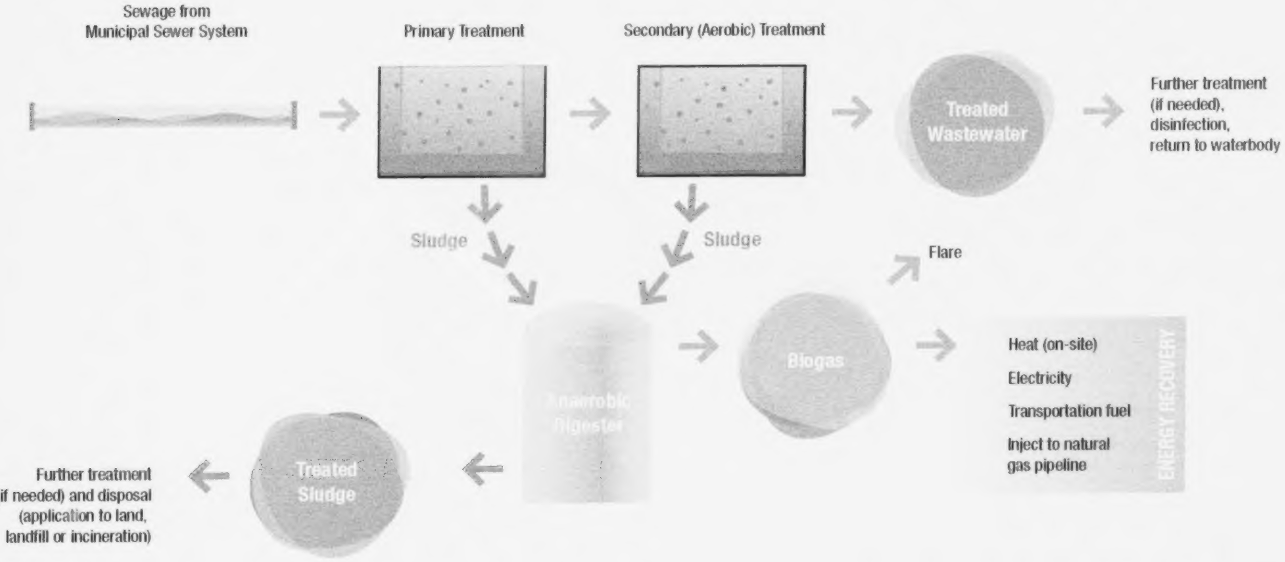

Sewage from
Municipal Sewer System
Primary Treatment
Secondary (Aerobic) Treatment
Treated Wastewater
Further treatment (if needed), disinfection, return to waterbody
Sludge
Sludge
Flare
Anaerobic Digester
Biogas
Heat (on-site)
Electricity
Transportation fuel
Inject to natural gas pipeline
ENERGY RECOVERY
Treated Sludge
Further treatment (if needed) and disposal (application to land, landfill or incineration)

Figure 8.1. Anaerobic digestion and energy recovery from wastewater treatment

ECO Recommendations

Making Energy Reporting Work (Chapter 3)

The Ministry of Energy should make O. Reg. 397/11 energy reporting for municipal water and wastewater systems more accurate and useful by including:

- pumping facilities;
- energy produced on-site (e.g., biogas, solar), not just purchased energy; and
- methane, nitrous oxide, and fossil-source carbon dioxide emissions from wastewater.

The Ministry of Energy should enable or require municipal water and wastewater systems to report under O. Reg. 397/11 through Portfolio Manager and require municipalities to report their annual energy use on a timelier basis.

The Ministry of the Environment and Climate Change should include energy efficiency in the training and licencing requirements for drinking water and wastewater system operators.

Can Asset Management Improve Energy Efficiency? (Chapter 4)

As part of municipal asset management planning for water and wastewater infrastructure, the Ministry of Infrastructure should require consideration of:

- Energy and carbon costs in life-cycle cost analysis;
- Green infrastructure and non-infrastructure alternatives such as water conservation.

In water and wastewater infrastructure projects supported by provincial funding, the Ontario government should require consideration of opportunities to reduce energy use and greenhouse gas emissions.

Water Conservation
(Chapter 5)

The Ministry of Municipal Affairs should amend the Ontario Building Code to place a greater emphasis on water efficiency and conservation, giving particular consideration to:

- Higher efficiency standards for fixtures, particularly toilets;
- Reducing summer peak outdoor water use;
- Ensuring that the plumbing design of multi-unit buildings is compatible with water metering of individual units;
- Expanding opportunities for reuse of greywater and rainwater, including greywater-ready plumbing design.

The Ministry of the Environment and Climate Change should: set water efficiency standards for toilets that apply at point-of-sale; and require water use reporting and water conservation plans for all broader public sector organizations and integrate this seamlessly with existing energy reporting requirements.

The Independent Electricity System Operator and gas and electric utilities should assess opportunities to integrate delivery of water conservation initiatives with existing energy conservation programs, particularly for whole home retrofits.

Water Reuse
(Chapter 6)

The Ministry of the Environment and Climate Change should establish appropriate standards for water reuse.

Phosphorus
(Chapter 7)

The Ministry of the Environment and Climate Change should implement phosphorus reduction programs that reduce loadings to sensitive surface waters, in a way that minimizes the energy use, financial costs, and greenhouse gas emissions needed to achieve reductions.

Energy from Sewage
(Chapter 8)

The Ministry of Infrastructure should make anaerobic digestion and energy recovery technology eligible for water/wastewater infrastructure funding.

The Ministry of the Environment and Climate Change should, without reducing environmental protection, simplify the regulatory approvals process for energy recovery systems associated with anaerobic digestion at wastewater treatment plants, including systems that co-digest off-site organics.

The Ontario Energy Board should set a renewable natural gas content requirement and cost recovery criteria for gas utilities.

On energy use, GHG emissions, and fresh water demand, municipal water and wastewater systems can become less of the problem and more of the solution. Ontario should not waste this once-in-a-generation opportunity.

Chapter 1

Introduction: Energy, Greenhouse Gas Emissions, Fresh Water, and Money

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What does drinking water cost?

Energy, greenhouse gas emissions, fresh water, and money

1.1 Energy, Greenhouse Gas Emissions, Fresh Water, and Money

Blessed to live in a water-rich province that includes the Great Lakes, most Ontarians take clean, cheap, safe, water for granted. This is especially true for the 85% of Ontarians (~11.6 million people)[1] who have unlimited clean water delivered to their taps by their municipal governments, and who can flush unlimited wastewater back into municipal pipes. Ontarians are heavy water users, consuming at least 50% more water than many Europeans.[2]

Most Ontarians take clean, cheap, safe, water for granted.

High water use has energy, climate, environmental and financial consequences that few Ontarians recognize. In 2017, the World Economic Forum ranked water crises (and failing to mitigate and to adapt to climate change) as three of the top five risks facing the world in the next decade.[3] The International Energy Agency's *World Energy Outlook 2016* dedicated an entire chapter to the global connection between water and energy. Among other things, it highlighted the energy dependence of the water sector, and the size of its environmental footprint. It also highlighted the urgency, and the opportunities, for the global water sector to reduce its greenhouse gas (GHG) emissions and increase its energy efficiency, energy production, and water conservation.[4]

This report examines the same themes in the Ontario municipal water context, including:

- the energy and GHG intensity of the water sector;
- the energy challenges of preserving fresh water quality; and,
- the significant potential for saving energy, GHG emissions, water and money in the water sector.

High water use has energy, climate, environmental and financial consequences.

1.1.1 Energy

Since 2011, Ontario municipalities have been required, by Ontario Regulation 397/11, to report energy purchased and GHGs emitted from their buildings and operations, although not from their transit systems or fleets.[5] The ECO has made this data accessible to the public through an interactive map, available at eco.on.ca/maps/2016-lets-get-serious/.

Municipal water and wastewater systems are typically the largest energy uses reported by Ontario municipal governments (see Table 1.1 and Figure 1.1). They use far more energy than street lighting or municipal office buildings (see Figure 1.2). Toronto's water and wastewater facilities use almost half as much energy as the entire Toronto Transit Commission.[6]

Across Ontario in 2011, water and sewage treatment facilities and pumping facilities used about 1,800 gigawatt-hours (GWh) of electricity (the equivalent of powering approximately 200,000 homes)[7] and 40 million m^3 of natural gas (the amount needed to heat approximately 15,000 homes).[8] This is equal to about 38% of reported municipal energy consumption (see Table 1.1 and Figure 1.1).

Table 1.1. Ontario Municipal Energy Use by Facility Type (2011)

Municipal Energy Use	eGWh	% of Overall
Water & wastewater treatment & pumping	2,235	**38%**
Administrative offices	765	**13%**
Ice arenas	599	**10%**
Indoor recreation facilities	579	**10%**
Storage facilities	462	**8%**
Community centres	348	**6%**
Police stations	243	**4%**
Libraries	193	**3%**
Fire stations	193	**3%**
Swimming pools	155	**3%**
Cultural facilities	92	**2%**
Ambulances	64	**1%**

Note: Energy use reported in equivalent gigawatt-hours (eGWh), combining multiple energy sources.

Source: Ministry of Energy, O. Reg. 397/11, 2011 normalized data.

> Municipal water and wastewater systems are typically the largest energy uses reported by Ontario municipal governments.

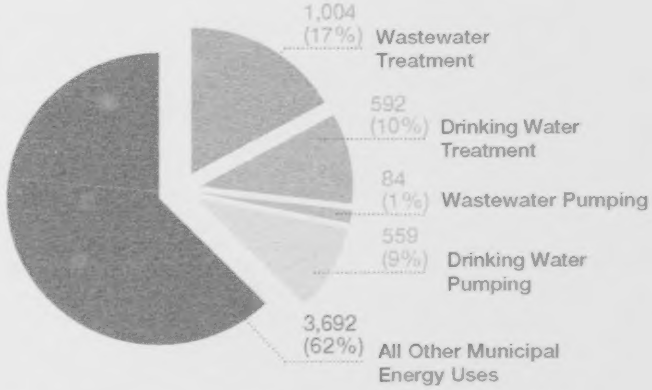


Figure 1.1. Ontario municipal energy consumption by facility type, 2011.

Note: "Other energy uses" include police stations, administrative buildings, community centres, and so on. It does not include municipal fleets or transit systems, for which energy use reporting is not yet required.

Source: O. Reg. 397/11, 2011 normalized data.

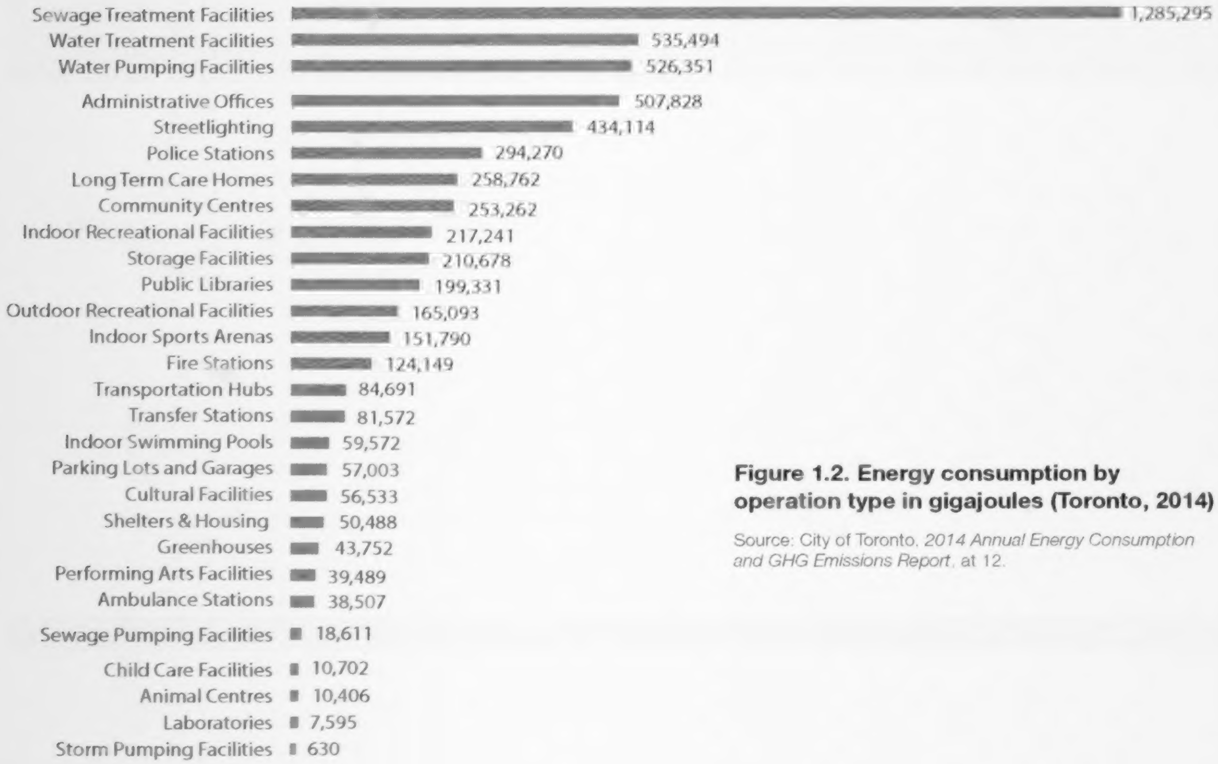


Figure 1.2. Energy consumption by operation type in gigajoules (Toronto, 2014)

Source: City of Toronto, *2014 Annual Energy Consumption and GHG Emissions Report*, at 12.

1.1.2 Greenhouse Gas Emissions

As was highlighted in our 2016 report *Facing Climate Change*, Ontario urgently needs to reduce GHG emissions and transition to a low-carbon economy. Municipal water and wastewater systems are underestimated sources of GHGs.

According to the O. Reg. 397/11 reports, municipal water and wastewater systems are responsible for about 32% of municipal GHG emissions,[9] reaching as high as 58% in Durham Region, which also handles wastewater treatment for much of York Region (see Figure 1.3). Water and wastewater systems were the largest source of GHG emissions for the City of Toronto at 37% in 2014 (see Figure 1.4).

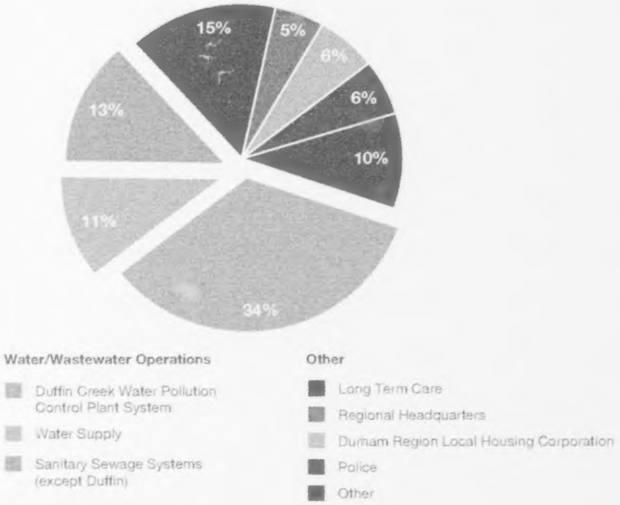


Figure 1.3. Distribution of greenhouse gas emissions by sector (Durham Region, 2015)

Source: Region of Durham, *Annual Energy Usage Report 2015*, at 11.

Note: About 80% of the sewage treatment undertaken at Duffin Creek Water Pollution Control Plant is on behalf of York Region.

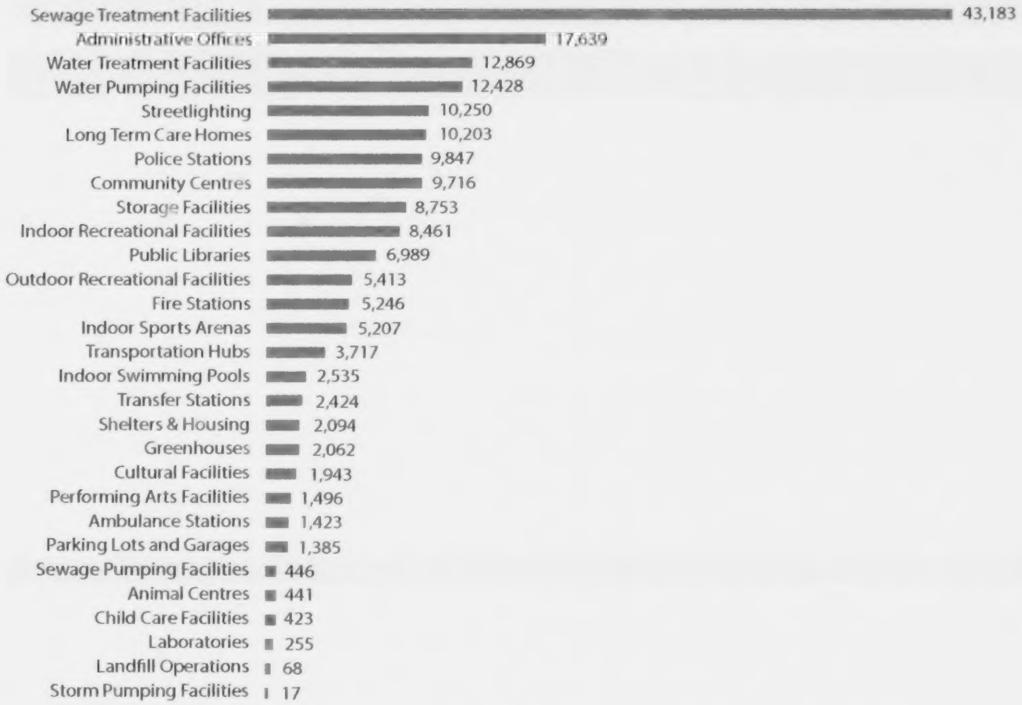


Figure 1.4. Greenhouse gas emission by building type (tonnes of CO_2) (Toronto, 2014)

Source: City of Toronto, *2014 Annual Energy Consumption and GHG Emissions Report*, at 14.

> Municipal water and wastewater systems are underestimated sources of GHGs.

As large as these numbers are, they still underestimate the real climate impact of municipal water systems, because the emissions reported under O. Reg. 397/11 only include GHGs from the energy purchased by municipal water systems. GHGs emitted from the wastewaters themselves or from the resulting biosolids (e.g., process emissions as bacteria consume organic wastes) are not reported.

National and provincial GHG inventories do include estimates of the GHGs emitted from wastewater (primarily methane and carbon dioxide), but these estimates also understate the climate footprint of municipal wastewater.

For example:

1. These inventories systematically underestimate methane because they report it as if one tonne of methane were equivalent to 21 or 25 tonnes of CO_2, when 86 tonnes of CO_2 would be a more appropriate multiplier,[10] and
2. The federal methodology incorrectly assumes that GHGs are emitted only from lagoons and septic tanks, and from nowhere else in municipal wastewater systems.

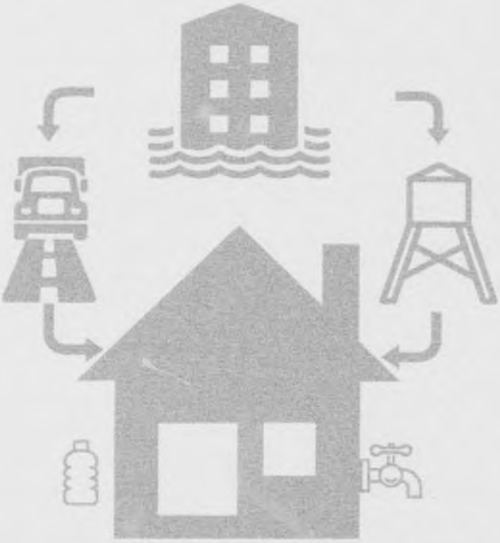
1.1.3 Tap Water vs. Bottled Water: A Clear Environmental Choice

Despite the high energy use of municipal water systems, Ontario tap water has a much lower energy and GHG footprint than bottled water.

A bottled water industry-funded study, adjusted to account for the GHG emissions of Ontario electricity, suggests that the GHG intensity of Ontario's tap water is about 40 times better than bottled water.[11] That's quite a difference. Nevertheless, the assumptions built into this study underestimate the advantage of tap water. For example, the study assumes that each tap water drinker wastes half the water coming from the tap,[12] and washes the glass in an inefficient dishwasher[13] after each and every use. Such wasteful behaviour would add a lot of mostly avoidable GHGs to tap water.[14]

On the other hand, international comparisons using life cycle assessment (LCA),[15] a standard method for comparing the environmental impacts of products, show that bottled water produces about 180 times the GHG emissions of tap water, when arriving at the household (i.e., excluding the impacts of dishwashing and tap water waste within the house, as well as the impact of producing a reusable glass for drinking).[16] In Ontario,[17] this difference is likely much larger, possibly reaching 1,000 times.[18] Why? Most of the energy used to extract, treat and transport tap water is electricity, and Ontario electricity has unusually low GHG emissions (90% nuclear/hydro/renewables). In contrast, bottled water in Ontario is transported by truck, using fossil fuels.[19] For bottled water, GHG emissions rise with shipping distance. Emissions also increase if smaller or heavier containers are used (and vice versa), due to both the increased use of plastic and higher transportation energy use.

Most Ontarians benefit from clean, safe, municipal drinking water. Bottled water may be essential where tap water is not available or is not safe (e.g., if it is contaminated by lead pipes or subject to a boil water advisory). For the rest of us, the environmental choice is clear.



AVERAGE LIFE CYCLE GHG EMISSIONS

1 litre of bottled water
=
40 – 1000 litres of tap water

Figure 1.5. Greenhouse gas impact of tap water versus bottled water

Water demand, land use development, and climate change are having significant impacts on Ontario's water resources.

1.1.4 Fresh Water

Water demand, land use development, and climate change are having significant impacts on Ontario's water resources, with related effects on municipal water systems. For example,

1. Hotter, drier summers can both increase demand and reduce the supply of water at the critical summer peak, as happened in some areas during the hot summer of 2016.[20] Ontarians, especially those located away from freshwater lakes, can no longer assume that they will always have as much water as they want whenever they want it.
2. Climate change is worsening algal blooms[21] by creating warmer, more nutrient-rich surface waters. Over 90% of the additional heat trapped by greenhouse gases has been absorbed in the Earth's waterbodies, and Ontario's waters are soaking up heat faster than the global average.[22] Extreme rain events and faster spring melts can flush higher nutrient loadings into this warmer water from urban and agricultural run-off.[23] The combination can affect both the water quality available for intake, and the ability of receiving waters to accept nutrients. Both, in turn, can trigger energy-intensive impacts on drinking water and wastewater treatment.[24]

1.1.5 Money

The energy used to operate water and wastewater systems costs Ontario municipal taxpayers about $260 million dollars each year, in addition to the huge capital costs to build the treatment and distribution infrastructure.[25] These costs are likely to rise, because:

- Energy prices are rising, particularly for electricity;
- Much of the existing water system infrastructure is ageing, leaking and increasingly inefficient;[26]
- More stringent regulatory standards and poorer-quality water bodies necessitate more energy-intensive treatment; and
- Populations across Ontario continue to grow. The Greater Golden Horseshoe Area is expecting dramatic population growth – 40% to 50% more people in just the next 23 years.[27] Serving this new population will need expensive new water infrastructure.

The good news is that some costs can be reduced through operational and infrastructural improvements of municipal water systems, and through greater water conservation. There are also major opportunities to use cleaner energy to lower both municipal GHG emissions and energy costs:

- by tapping the energy potential of sewage, and
- by shifting electricity-intensive plant operations to times when electricity is both cheaper and cleaner.

Indeed, the possibilities for increased energy efficiency and GHG reductions in the sector are significant. Some cities have been able to achieve net-zero energy and GHG municipal water cycles. For example, Aarhus, Denmark (pop. 320,000) has an energy neutral water cycle, due to energy efficiencies throughout its treatment and pumping systems, and by turning its wastewater plants into energy producers.[28]

The energy costs to operate water and wastewater systems are likely to rise.

Ontario now has a once-in-a-generation opportunity to cut energy costs and reduce the environmental footprint of municipal water and wastewater systems.

1.2 A Once-in-a-Generation Opportunity

Ontario now has a once-in-a-generation opportunity to cut energy costs and reduce the environmental footprint of municipal water and wastewater systems, while placing these vital systems on a more sustainable footing.

- Major water system investment is expected in the next few years. New funding opportunities, in particular the federal Long-Term Infrastructure Plan (e.g., the Clean Water and Wastewater Fund)[29] funding, with additional contributions from the Ontario goverment, will provide a time-limited window to incorporate energy efficiency and GHG reductions in plant upgrades. Once a water system design is locked in, the opportunity could be lost for a generation or more.
- Many municipal water systems are nearing the end of their useful life or are suffering from deferred maintenance.[30]
- The information needed to seize the opportunity to reduce energy use and GHG emissions is becoming available due to:
    - Technology for data access, data management, data analysis and benchmarking, such as automated plant monitoring and control systems (e.g., SCADA control systems) and Portfolio Manager;
    - Growing use of asset management planning, which can help municipalities understand and minimize their water system life-cycle costs; and
    - Mandatory energy reporting regulation (O. Reg. 397/11) in the broader public sector. Although imperfect, the reported data shows a wide variation in the energy intensity of Ontario's water and wastewater systems, suggesting a large potential for improvements in energy efficiency.
- Additional funding and support for energy efficiency and clean energy may be available through other sources, including:
    - Enhanced utility energy conservation programs under the 2015-2020 Conservation First Framework budget and program, described in Chapter 2 of the ECO's 2015/2016 Energy Conservation Progress Report: *Let's Get Serious*; and,
    - The Ontario Energy Board's expected inclusion of renewable natural gas (including biogas) in the supply portfolio of natural gas distributors.
- Ontario has a legal framework it could quickly use to prioritize water-energy efficiency (the *Water Opportunities and Water Conservation Act, 2010*).

The province should do everything it can to ensure the opportunity to improve the energy efficiency and reduce the GHG emissions of Ontario's water and wastewater systems is seized, while minimizing negative impacts on human health or on the natural environment.

1.3 Purpose and Scope of the Report

This report examines the municipal water cycle (see Chapter 2, Figure 2.1) with the key goals of:

1. Making Ontarians aware of the major energy, climate, environmental and financial consequences of using municipally-treated water, and the importance of being thoughtful in our use of water; and
2. Advising the province, municipalities, and Ontarians about what they can do to reduce these consequences, while maintaining protection for the environment and human health.

This report comments on activities which fall primarily under the responsibility of the Ministries of the Environment and Climate Change, Energy, Infrastructure, and Municipal Affairs, within the Ontario government.

Energy use in First Nations water and wastewater systems or in private systems (e.g., individual wells) are not covered in the report; see Textbox 1.3.1 and 1.3.2.

In our analysis, we rely on data gathered from many sources (see individual chapter endnotes), namely:

- Consultation with dozens of experts in the field (see Thanks and Acknowledgments);
- Municipal energy reports;
- A survey of municipalities (see Textbox 1.4.1);
- Provincial government ministries and agencies;
- Energy use data reported to the province via O. Reg. 397/11;
- Statistics Canada for water use data;
- Peer-reviewed journals; and,
- Numerous reports from governments, non-governmental organizations, and industry.

1.3.1 Energy Use in First Nations Water and Wastewater Systems

This report focuses on policy issues related to energy use in municipal water and wastewater systems. It does not deal with energy use in water and wastewater systems in on-reserve First Nations communities, as the policy levers are very different.

In particular,

- The federal government has primary responsibility for funding on-reserve water and wastewater infrastructure. Provincial asset management planning rules will not apply to First Nations.
- Provincial water standards and regulatory programs do not apply to on-reserve water systems.
- On-reserve communities do not have energy reporting requirements under O. Reg. 397/11.

The Ontario government does play a supporting role in providing technical assistance through the Indigenous Drinking Water Projects Office, and (through the Ontario Clean Water Agency) acting as a service provider in the operations of many on-reserve water systems. It is also providing some infrastructure funding as part of the provincial component of the Clean Water and Wastewater Fund.

Access to safe drinking water remains the primary water issue for many First Nations, with long-term boil advisories in 24 First Nations communities as of September 2016.[31] The 2016 federal budget committed $1.8 billion over five years for on-reserve water and wastewater infrastructure to address health and safety needs.[32]

Despite these differences, reducing energy use and improving energy efficiency in water and wastewater operations is also beneficial for First Nations communities. This is particularly the case for remote off-grid First Nations, where water and wastewater systems are typically powered by inefficient, expensive and carbon-intensive diesel generators. Many of these communities have diesel plants running near capacity, and energy efficiency can free up supply for other uses. In addition, providing these communities with connections to the provincial power grid, and/or with local microgrids based on renewable energy or natural gas, can dramatically improve their air quality, energy cost and quality of life, as well as reducing greenhouse gas emissions. The ECO welcomes the federal government's 2016 announcement of funding for such local microgrids.[33]

1.3.2 The Tip of the Iceberg

Municipal water and sewage systems are just one part of the water-energy nexus. There is also the other side of the water-energy nexus: the water footprint of energy production. Indeed, the largest water users in Ontario are hydro and thermal (including nuclear) generation facilities (see Figure 1.6).

Water is also extracted from the natural environment by many other users, including:

- Manufacturing facilities;
- Agriculture; and,
- Private residential water systems.

In these cases, the energy costs for pumping and treatment, and for wastewater treatment and disposal, are borne by the end users, including the 15% of Ontarians not served by municipal systems. A 2010 Polis Institute report *(Ontario's Water-Energy Nexus)* estimated the total energy used for private pumping and treatment in Ontario is about two-thirds that of the energy used for municipal systems. The water use by these sectors also affects water availability for municipal systems in the province, especially during peak irrigation season within groundwater-dependent regions of the province, further driving the need for water conservation efforts (discussed in Chapter 5).

There is also extensive use of energy within residential, commercial and industrial buildings to heat water and to produce steam; however, reducing energy use to heat water is already a major focus of natural gas conservation programs.

These other aspects of the water-energy nexus are generally outside the scope of this report, although water conservation actions that reduce hot water use (e.g., more efficient water fixtures), will reduce both the direct use of energy by the final consumer, and the energy used indirectly within the municipal system, and will be discussed to some extent in Chapter 5.

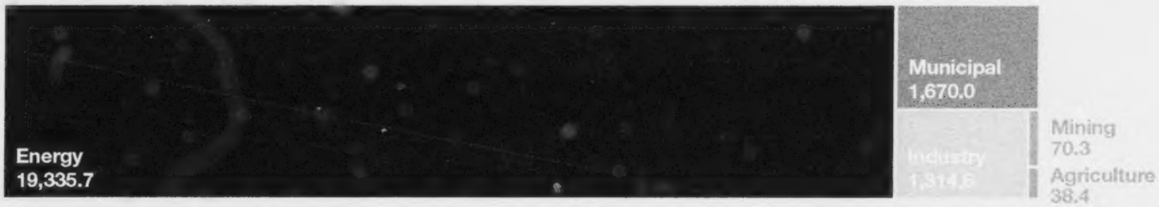


Figure 1.6. Water consumption by sector in Ontario (in million cubic metres, 2011)

Source: Statistics Canada, *Survey of Drinking Water Plants*, Catalogue 16-403-X (2011) Table 1-1; *Industrial Water Use*, Catalogue 16-401-X (2011) Table 5-1, Table 19, and Table 29; *Agriculture Water Use in Canada*, Catalogue 16-402-X (2012) Table 1-1.

Note: Energy, Agriculture, Industry, and Mining exclude water supplied by municipal water systems.

1.4 Structure of the Report

- **Chapter 2, The Municipal Water Cycle** describes the municipal water cycle and how energy is used at each stage.
- You can't manage what you don't measure. **Chapter 3, Making Energy Reporting Work** looks at energy reporting requirements for water and wastewater facilities, and examines how municipalities can better monitor, benchmark, and understand their energy use and greenhouse gas emissions, and act on this information.
- Ageing and poorly maintained water infrastructure is endemic across Canada,[34] and investment in more sustainable water systems often loses out to other competing demands for government funds. In Ontario, leaking pipes alone account for at least 10% of water use, wasting energy and water.[35] **Chapter 4, Can Asset Management Improve Energy Efficiency?** reviews how to prioritize energy efficiency and GHG reductions in municipal asset management planning and capital investment.
- Ontarians are profligate water consumers, averaging about 200 litres/per person/day[36] for residential use, compared to just over 100 litres in some leading European cities.[37] Water conservation programs, strengthened codes and standards, and pricing mechanisms can help reduce water use, related energy costs, and strain on those regions in Ontario at risk of source water quantity threats, as discussed in **Chapter 5, Water Conservation.**
- Water reuse avoids energy-intensive steps in the water cycle, but currently plays only a minor role in meeting Ontario's water needs. **Chapter 6, Water Reuse** discusses whether and how the province can enable more water reuse.
- Increasing temperatures and major rainfall events mean Ontario's largest water sources – our lakes – need better protection from toxic algal blooms, which are driven by phosphorus inputs from the surrounding watershed. Wastewater treatment facilities represent a small fraction of overall phosphorus loading to Ontario's lakes, yet carry the heavy energy and infrastructure costs of disproportionately stringent point-source phosphorus regulation. Providing municipalities with flexibility in how to reduce phosphorus releases can save energy and reduce GHG emissions without compromising environmental quality, and is discussed in **Chapter 7, Phosphorus.**
- Wastewater treatment facilities present a major opportunity to reduce greenhouse gas emissions (and thus the municipal carbon footprint) by capturing biogas for renewable energy. Biogas, discussed in **Chapter 8, Energy from Sewage**, can offset internal energy use and costs, or create a municipal revenue stream by selling the energy into the natural gas or electricity system.

Together, these chapters explore opportunities to reduce the energy and climate footprint of Ontario's water use from three main avenues:

- Improving energy efficiency (energy used per volume of water);
- Using cleaner energy sources; and
- Reducing the amount of water treated and pumped.

1.4.1 ECO's 2017 Municipal Water-Energy Efficiency Survey

To better understand the varied experiences of Ontario municipalities in managing the energy intensity of their drinking water and wastewater systems, the ECO surveyed Ontario municipalities in early 2017.

About 25% of Ontario municipalities responded, representing over 70% of the provincial population served by municipal drinking water and wastewater systems.

In addition to our literature research and stakeholder consultations, these survey responses helped shape the recommendations made throughout this report.

Appendix A provides a summary of the survey questions and responses.

Endnotes

1. Statistics Canada estimates 11,603,632 Ontarians were served by municipal drinking water plants. See: Statistics Canada, *Population served by drinking water plant, by source water type for Canada, provinces, territories and drainage regions*, Table 153-0106 (Ottawa: Statistics Canada, 2013).

2. Ontarians use about 200 litres per capita per day. See: Statistics Canada, *Potable water use by sector and average daily use for Canada, provinces and territories*, Table 153-0127 (Ottawa: Statistics Canada, 2013). Compared to,

    - **Copenhagen, Denmark:** 108 litres/capita/day in 2010. See: European Union, Copenhagen, *European Green Capital Application* (European Union, 2012) at 3, online: <ec.europa.eu/environment/europeangreencapital/wp-content/uploads/2012/07/Section-8-Water-Consumption_Copenhagen.pdf>.
    - **Hamburg, Germany:** 110 litres/capita/day in 2006. See: European Union, Hamburg, *European Green Capital Application* (European Union, 2011) at 1, online: <ec.europa.eu/environment/europeangreencapital/wp-content/uploads/2011/05/EGC-application_Hamburg_dec08_07.pdf>.
    - **Nantes, France:** 122 litres/capita/day in 2008. See: European Union, Nantes, *European Green Capital Award* (European Union, 2011) p.138, online: <ec.europa.eu/environment/europeangreencapital/wp-content/uploads/2011/05/EGCNantesUKChap9-F.pdf>.
    - **United Kingdom:** 150 litres/capita/day in 2007. See: United Kingdom, Environment Agency, *International comparisons of domestic per capita consumption* by Aquaterra (UK Environment Agency, 2008) at 4, online: <webarchive.nationalarchives.gov.uk/20140328084622/http:/cdn.environment-agency.gov.uk/geho0809bqtd-e-e.pdf>.

3. World Economic Forum, *The Global Risks Report 2017, 12th Edition* (Geneva: WEF, 2017) Figure 2.

4. International Energy Agency, *World Energy Outlook 2016* (Geneva: IEA, 2016) Chapter 9 "Water-Energy Nexus".

5. The ECO has recommended that municipal fleet use should be reported. See: Environmental Commissioner of Ontario, *Annual Energy Conservation Progress Report- 2015/2016, Let's Get Serious* (Toronto: ECO, 2016) at 50.

6. Based on a comparison of the TTC's 2012 and 2013 total energy use. See: Toronto Transit Commission, *Sustainability Report 2013* (Toronto: TTC, 2013) at 11.

7. The Ontario Energy Board uses 750 kWh/month (9000 kWh/year) as the electricity consumption of a typical residential account. See: Ontario Energy Board, *Defining Ontario's Typical Electricity Consumer*, EB-2016-0153 (Toronto: OEB, 14 April 2016) at 1.

8. Based on assumptions and data from Natural Resources Canada. See: Natural Resources Canada, "Natural Gas: A Primer", updated 27 November 2015, online: <www.nrcan.gc.ca/energy/natural-gas/5641#home>.

9. Though more current data is available, 2011 data is most often referenced in this report as it is the year for which the most comprehensive data was collected for water and wastewater systems under O Reg 397/11. See: Chapter 3.

10. The Canadian National Inventory Report uses a GWP of 24, Ontario's reporting regulation uses a GWP of 21. A GWP of 86 is based on the IPCC AR5 using a 20-year time horizon. See: Environmental Commissioner of Ontario, *Facing Climate Change: Greenhouse Gas Progress Report 2016* (Toronto: ECO, 2016) at 52.

11. Based on an extrapolation of the results from an LCA for tap water and generic bottled water, substituting the 43 g CO_2 eq/kWh GHG intensity of Ontario electricity consumption. See, Nestle Waters, *Environmental Life Cycle Assessment of Drinking Water Alternatives and Consumer Beverage Consumption in North America* by Quantis (Nestle Waters North America Project Report, 2010) Figure 22 at 46; Environment and Climate Change Canada, *National Inventory Report 1990-2014: Greenhouse Gas Sources and Sinks in Canada,* Part 3 (Ottawa: ECCC, 2017) at 99. The LCA results are based on an average water and wastewater electricity intensity (0.00039 kWh/L at 14), which is comparable to Ontario data reported under O Reg 397/11.

12. Nestle Waters, *Environmental Life Cycle Assessment of Drinking Water Alternatives and Consumer Beverage Consumption in North America* by Quantis (Nestle Waters, 2010) at 17.

13. The Nestle 2010 LCA assumed that the dishwasher used 1.8 kWh/load. In comparison, the current Energy Star certification standard assumes that a standard dishwasher uses approximately 1.26 kWh per load (based on the 270 kWh/year criterion, and an assumption of 215 cycles per year). See: "Dishwashers Key Product Criteria", online: Energy Star <www.energystar.gov/products/appliances/dishwashers/key_product_criteria>. [Accessed 5 May 2017]

14. About 7 g CO_2 eq/litre, based on an extrapolation of the results in Nestle (2010) for tap water, and using the 2015 GHG intensity of Ontario's electricity consumption. This result would vary greatly with the efficiency of the dishwasher (addressed in the LCA study).

15. Life cycle assessments (LCAs) are frequently used to answer the question "Which product is more environmentally-friendly?" Unlike other methods of evaluating environmental performance, LCAs address impacts across the full life cycle – i.e., those associated with material extraction, processing, transportation, use, and waste management.

16. The mean result from a comprehensive review of global tap and bottled water LCAs. See: Fantin et al, "A method for improving reliability and relevance of LCA reviews: The case of life-cycle greenhouse gas emissions of tap and bottled water" (2014) 476-477 *Science of the Total Environment* 228 at 238.

17. Using the same LCA assumptions and system boundaries as Fantin et al (2014).

18. The extraction, treatment and distribution of tap water, using the 2015 Ontario electricity consumption GHG intensity (43 g CO_2 eq/kWh), results in approximately 0.25 g CO_2 eq/litre (based Nestle (2010), Figure 35 at 65), about 1000 times better than the 260 g CO_2 eq/litre life cycle GHG emissions from generic bottled water (based on Nestle (2010), Figure 22 at 46, substituting the 43 g CO_2 eq/kWh GHG intensity of Ontario electricity consumption). The data from the Quantis 2010 LCA was often displayed graphically (i.e., Figures 22 and 35). Care was taken in measuring the displayed results manually, nonetheless, the ECO's extrapolated results are approximations.

19. For just one component of the life cycle – delivery to users, the ECO calculated that tap water produces about 3,600 times fewer GHG emissions than bottled water from Ontario. The ECO based this estimate on the average GHG emissions per litre of tap water piped to households from water pumping stations in the City of Toronto in 2014. See: Ministry of Energy, O Reg 397/11, 2014 raw data. For the bottled water, we

    (1) weighed a 1.5 litre PET water bottle and its associated packaging,

    (2) took into account the average emissions from transporting freight on heavy duty trucks in Ontario (Natural Resources Canada, *National Energy Use Database*, 2014 data, Table 36)

(3) adopted a 250 km trucking distance, based on an estimate by an Ontario bottled water supplier (Nestle Waters Canada, News Release, "Nestle Waters Canada Eco-Shape® PET Bottle Wins CPIA 2010 Plastic Stewardship Award" (12 June 2010), online: <www.nestle-waters.ca/en/media/pressreleases/nestl%C3%A9waterscanadaeco-shape%C2%AEpetbottlewinscpia2010plasticsstewardshipaward>; and

(4) normalized the result so that the estimates are based on one litre of water supplied.

20. "Canada Drought Monitor" (updated monthly) online: Agriculture and Agri-Food Canada <open.canada.ca/data/en/dataset/292646cd-619f-4200-afb1-8b2c52f984a2>.

21. International Joint Commission, *A Balanced Diet for Lake Erie: Reducing Phosphorus Loadings and Harmful Algal Blooms* (IJC, 2014) at 5; International Joint Commission, Protection of the Waters of the Great Lakes: 2015 Review of the Recommendations from the February 2000 Report (IJC, 2015) at 12.

22. Lake Superior, for example, is one of the fastest warming lakes in the world; warming by 1.16 °C per decade. See: Catherine M. O'Reilly et al, "Rapid and highly variable warming of lake surface waters around the globe" (2015) 42 Geophysical Research Letters 10,773. (For the actual number for Lake Superior see p.13 of Supporting Information for Rapid and highly variable warming of lake surface waters around the globe.)

23. A.M. Michalak et al, "Record-setting algal bloom in Lake Erie caused by agricultural and meteorological trends consistent with expected future conditions" (2013) Proceedings of the National Academy of Sciences 6452.

24. In the case of wastewater treatment, see Chapter 7. In the case of drinking water treatment facilities, algal blooms may necessitate the use or increased use of UV light treatment. See: Sarah Fister Gale, "The blue-green monster: How harmful algal blooms are increasing costs, risks for WTPs", *WaterWorld* (19 May 2015) online: <www.waterworld.com/articles/print/volume-31/issue-5/features/the-blue-green-monster-how-harmful-algal-blooms-are-increasing-costs-risks-for-wtps.html>.

25. Based on an internal analysis of the 2011 O Reg 397/11 data.

26. A phenomenon experienced among most OECD countries. See: OECD, *Water and Cities, Policy Highlights* (OECD, 2015) at 2; The U.S. is experiencing a similar infrastructure investment gap. See: U.S. Department of Energy, *The Water-Energy Nexus: Challenges and Opportunities* (DOE, June 2014) at 75.

27. Ontario Ministry of Municipal Affairs, *Growth Plan for the Greater Golden Horseshoe* (Toronto: MMA, June 2013) Schedule 3.

28. Robin Whitlock, "Water and Energy: An Interview with Mads Warming of Danfoss Energy & Water", *Renewable Energy Magazine* (9 January 2017) online: <www.renewableenergymagazine.com/interviews/water-and-energy-an-interview-with-mads-20170109>.

29. Ontario has already received $570 million from the first phase of funding through the federal Clean Water and Wastewater Fund, and is expected to receive a further unknown share ("Phase 2"), targeted at helping municipalities achieve sustainable and innovative water and wastewater systems.

30. At least $80 billion is needed to upgrade or replace current water and wastewater systems; The last major investments in water infrastructure in Canada were 50-100 years ago. See: Canadian Water and Wastewater Association, *2012 Canadian Infrastructure Report Card, Public Attitudes Project 2015* (CWWA: Ottawa, 2015) at 4; Municipal water system leakage rates across Ontario can be as high as 40% (based on responses to the ECO's 2017 Municipal Water/Energy Survey), see Textbox 2.5.1.

31. Ontario Ministry of the Environment and Climate Change, "Minister's Annual Report on Drinking Water 2016", (MOECC, 2016), online: <https://www.ontario.ca/page/ministry-environment-and-climate-change-ministers-annual-report-drinking-water-2016#section-3>

32. Indigenous and Northern Affairs Canada, "Water in First Nation communities", online:<https://www.aadnc-aandc.gc.ca/eng/1100100034879/1100100034883>. [Accessed 8 May 2017]

33. Government of Canada, News Release, "Government of Canada Investment Supports Green Energy Solutions in Remote First Nations" (26 May 2016).

34. Forum for Leadership on Water, *Seizing Canada's Infrastructure Moment* by Tony Maas (FLOW, 2017) at 1.

35. Statistics Canada, *Potable water use by sector and average daily us for Canada, provinces and territories*, Table 153-0127 (Ottawa: Statistics Canada, 2013).

36. *Ibid.*

37. See Note 2.

Chapter 2

Energy Use in the Municipal Water Cycle

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Why do municipal water systems use so much energy?

Water is heavy; water systems are complex

2

Abstract

This brief chapter provides a basic overview of municipal drinking water and wastewater systems, with a focus on how they use energy, and examples of how they could be made more efficient and less carbon-intensive, or shift the timing of energy use to reduce cost and greenhouse gas emissions.

2.1 An Overview

The municipal water cycle includes:

- taking water from the natural environment;
- treating source water to meet drinking water regulatory requirements;
- delivering treated water to homes and businesses;
- collecting wastewater from homes and businesses; and
- treating wastewater to meet outflow requirements before discharge to the environment (see Figure 2.1).

Municipal water systems use a lot of energy, primarily because water is heavy to pump and we use energy-intensive methods to clean it. However, they do not need to use as much energy, particularly fossil fuel energy, as they do.[1]

Historically, water systems were not generally designed or operated with energy efficiency as a priority. Many plants were built in a time of lower energy costs and anticipated economic growth, and are now ageing, with deteriorating performance. Operators have been (rightfully) focused on meeting service standards and other regulatory requirements,[2] and on keeping costs low; energy efficiency is not even part of their mandatory training. Yet consistent with these other goals, municipal water systems have major opportunities for energy efficiency and/or greenhouse gas (GHG) reductions. Technological innovation has taken a great leap in the last 20 years leading to more efficient pumps, motors and other equipment. As illustrated in Figure 2.1, opportunities include:

- operational changes,
- equipment optimization or replacement,
- energy recovery systems,
- water conservation, and
- load shifting.

Load shifting (adjusting the timing of electricity use) can reduce GHG emissions and energy costs and is examined later in this chapter. The other opportunities are examined in later chapters of this report.

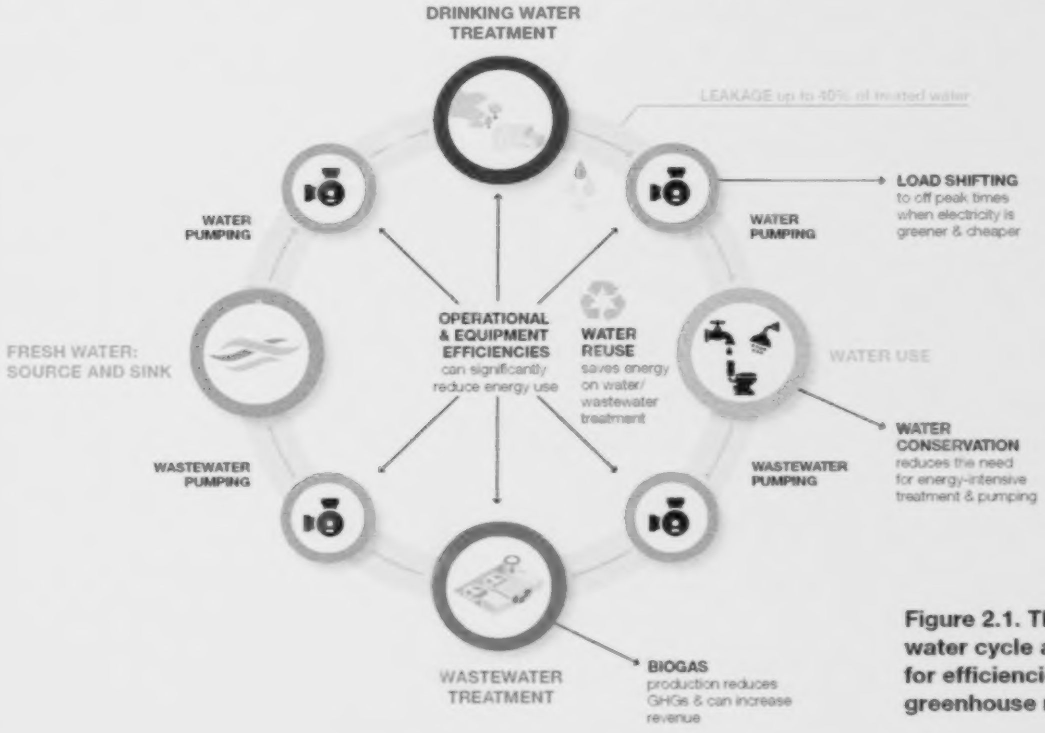

DRINKING WATER TREATMENT
LEAKAGE up to 40% of treated water
WATER PUMPING
WATER PUMPING
LOAD SHIFTING
to off peak times when electricity is greener & cheaper
FRESH WATER: SOURCE AND SINK
OPERATIONAL & EQUIPMENT EFFICIENCIES
can significantly reduce energy use
WATER REUSE
saves energy on water/ wastewater treatment
WATER USE
WATER CONSERVATION
reduces the need for energy-intensive treatment & pumping
WASTEWATER PUMPING
WASTEWATER PUMPING
WASTEWATER TREATMENT
BIOGAS
production reduces GHGs & can increase revenue

Figure 2.1. The municipal water cycle and opportunities for efficiencies and greenhouse reductions

2.2 How Much Energy do These Systems Use?

Each municipal water and wastewater system is unique. Their energy use is affected by many factors, including: population, density, local industry, source water characteristics, infrastructure age, design, treatment process type and system, maintenance level, and geography (distance and elevation). But they also share many common features.

Water and wastewater systems represent a large share of most municipalities' reported energy use (see Figure 2.2 and Chapter 3) and generate a significant portion of municipal GHG emissions (see Chapter 1, Figures 1.3 and 1.4). On average, in 2011, Ontario municipal water and wastewater systems represented:

- 38% of municipal energy use, and
- 32% of municipal GHG emissions.[3]

Similar statistics are reported in other jurisdictions, including the United States.[4]

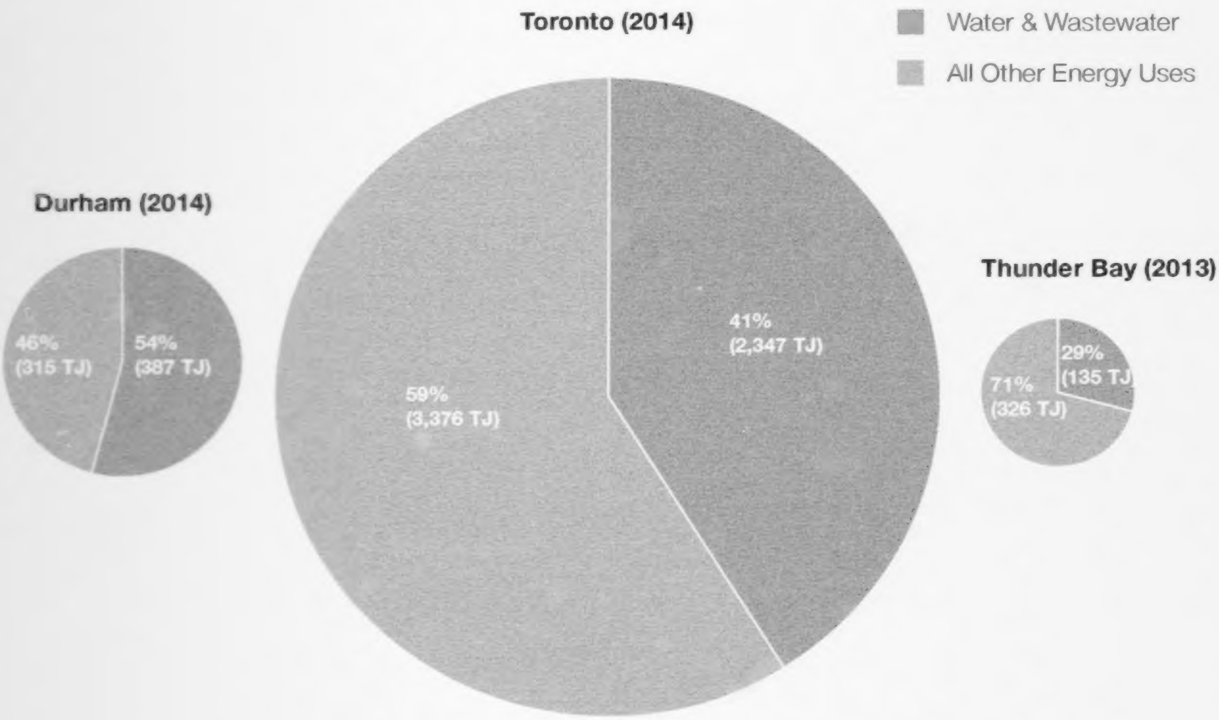


Figure 2.2. Examples of water and wastewater systems as a share of a municipality's overall energy use, in terajoules (Durham, 2014; Toronto, 2014; Thunder Bay, 2013)

Note: Area of circles is proportional to overall energy use. Reported data for "all other energy uses" is similar to categories reported in O. Reg. 397/11 and excludes fleet energy use.

Source: Internal municipal energy reporting (Toronto, 2014; Thunder Bay, 2014; and Durham, 2015).

Each stage of the cycle affects municipal energy use and GHG emissions (see Figures 2.3 and 2.4). The next sections will provide more detail about how each stage in the cycle works, including major energy uses and energy efficiency and GHG reduction opportunities.

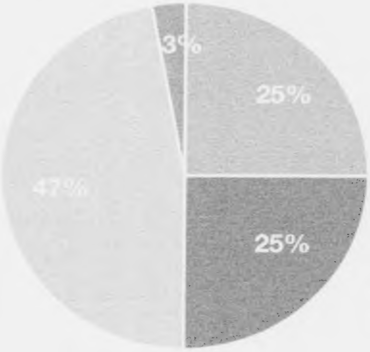


Figure 2.3. Distribution of reported water cycle greenhouse gas emissions (2011)

Source: Ministry of Energy, O. Reg. 397/11, 2011, normalized data.

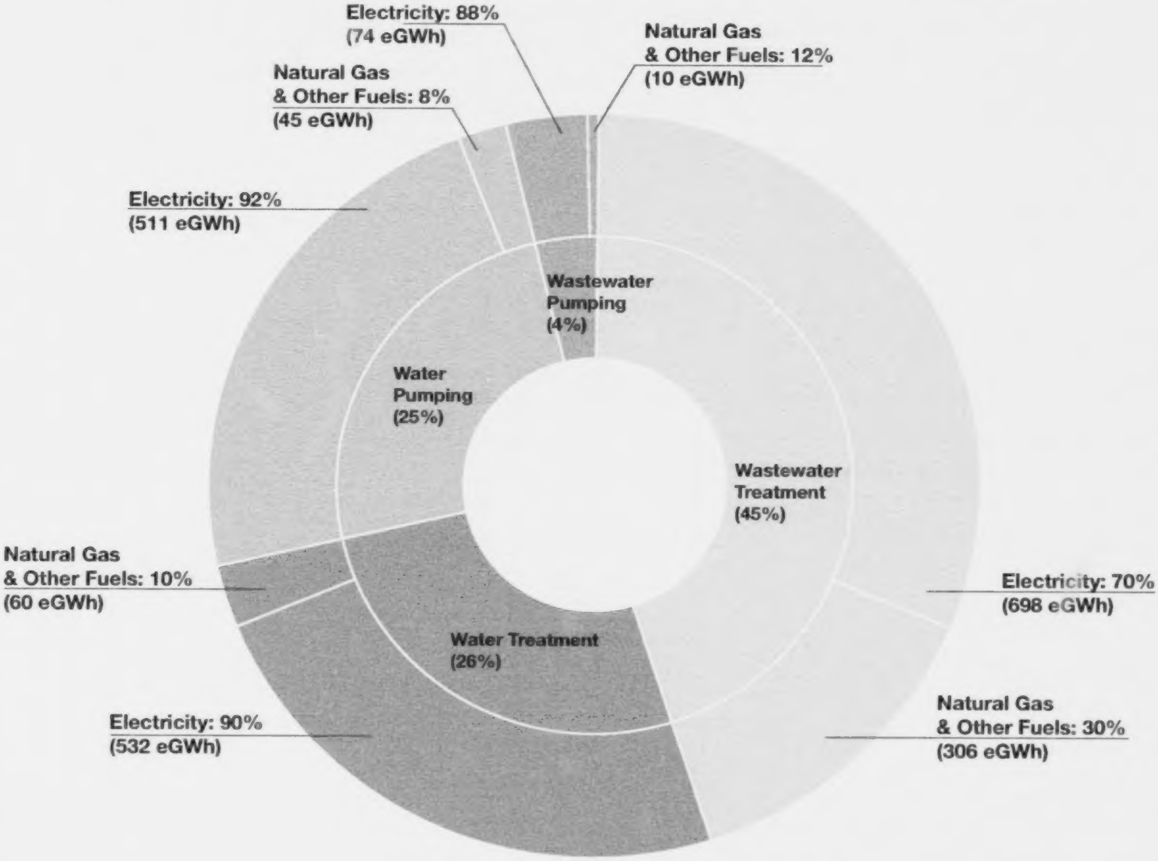


Figure 2.4. Ontario municipal water system electricity and natural gas consumption by facility type, in equivalent gigawatt hours (2011)

Source: Ministry of Energy, O. Reg. 397/11, 2011 normalized data.

Note: "Other fuels" includes diesel and fuel oil; they make up a small fraction of energy use in the sector. Renewable energy use is not included in this chart as it is not reported in O. Reg. 397/11 data.

2.3 Drinking Water Treatment

Drinking water treatment facilities filter and clean source water to achieve safe drinking levels. The energy used to treat drinking water depends primarily on the contaminant/turbidity level of the source water (groundwater is typically less contaminated than surface water due to natural filtration and settling). On average, they are the second biggest energy users in the municipal water cycle (see Figure 2.4). Drinking water treatment is primarily powered by electricity; natural gas is typically only used to heat the facility. Other fuels may be used for backup power generation.

As a first stage of treatment, large debris (like sticks) is removed using mechanical screens and then sedimentation is used to remove smaller debris like gravel, sand, and silt.[5] The collected debris must be removed, in some cases treated, then disposed of or recycled.[6] Water is then typically pumped through a series of filters (to remove smaller debris, biologic contaminants and turbidity) to a storage tank for disinfection (commonly via chlorination, and/or ultraviolet (UV) radiation or ozone) to destroy or inactivate microbial pathogens.[7]

Though a focus on pumping is important as it typically represents the largest single energy use within a water treatment facility, other worthwhile energy saving opportunities exist through operational and behavioral changes. For example, operators of the Region of Waterloo's Middleton Water Supply System (the region's largest groundwater treatment plant), found that by simply adjusting the power level of the system's UV lamps they were able to save $150,000 a year in energy costs, and reduce greenhouse gas emissions equivalent to 121 passenger vehicles driven for one year.[8]

2.4 Wastewater Treatment[9]

After water is used by consumers, energy is required to collect and then treat it so that it can be safely discharged back to the environment. Wastewater treatment tends to be the largest energy consumer and source of GHG emissions in the water cycle (see Figures 2.3 and 2.4).[10] However, its share of energy use is particularly affected by relevant treatment standards (see Chapter 7).

Wastewater can undergo several different levels of treatment before being discharged back into the natural environment or reused (Ontario's guidelines call for a minimum of secondary treatment[11]):

Preliminary:
Removal of large, coarse, heavy objects through bar screens. Aerated channels may be used for preliminary treatment to keep solids in suspension prior to primary treatment, particularly at larger sewage treatment works.[12]

Primary:
Removal of settleable and floating solids (a.k.a. sludge) via sedimentation tanks. The biggest energy use at this stage is sludge pumping.[13] Further treatment of the sludge, once it has been separated from the liquid, is described in the text below.

Secondary:
Biological processes (i.e., aerobic microorganism digestion) to remove dissolved organic matter (e.g., aeration tank, trickling filter and activated sludge process), typically followed by settling tanks. The highest energy user in the sewage treatment process is the aeration system associated with this treatment step (see Figure 2.5).[14]

Tertiary:
Additional treatment to remove nutrients, such as nitrogen, phosphorus and suspended solids through technologies including filtration (sand or membrane).

Quaternary:
Reverse osmosis technology, as used in desalination plants, designed to remove the smallest particulates present in water. This technology can be five times more energy intensive than tertiary treatment (see Chapter 7).

Disinfection:
The final step before discharge of the treated liquid (often using UV light treatment).

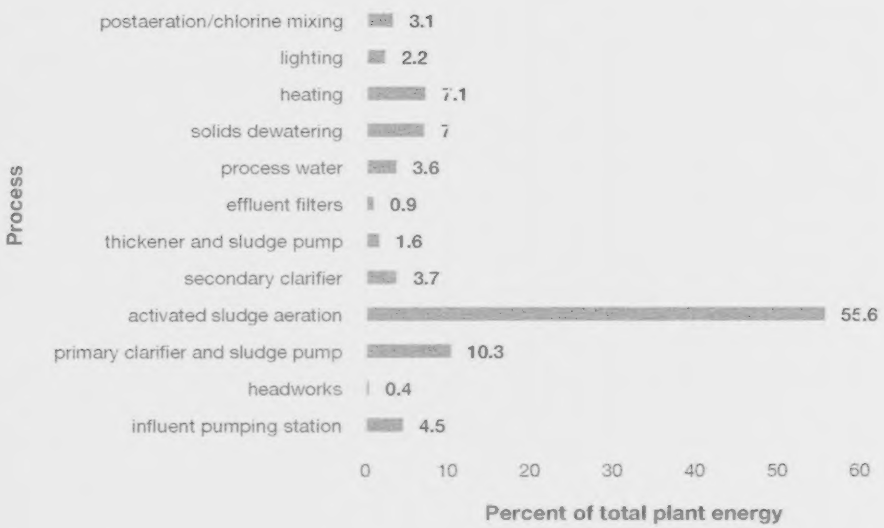


Figure 2.5. Average electricity use, by process, in a wastewater treatment facility

Source: *Wastewater Engineering Treatment and Reuse, 5th Edition* (Metcalf & Eddy, 2014) Figure 17-4.

About 85% of Ontarians are served by piped municipal wastewater systems. Of those, most are secondary treatment plants, some undertake tertiary treatment, and one is proposing a quaternary treatment facility.[15]

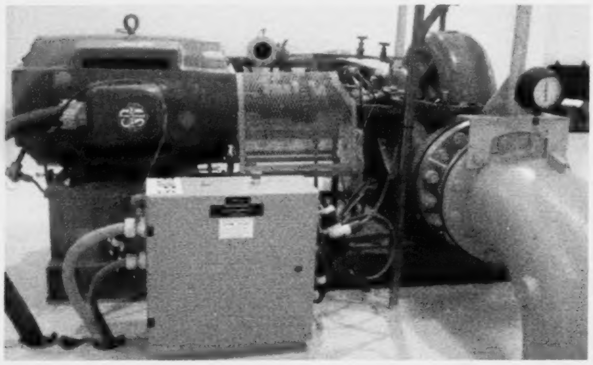
According to the IEA "about half of the energy used in advanced wastewater collection and treatment is consumed in secondary treatment, notably to satisfy the requirement for aeration in the biological step" (see also Figure 2.5).[16] An opportunity for many plants is to control aeration based on monitoring of dissolved oxygen levels, so that aeration equipment is not running needlessly. In combination with high-efficiency blowers, this can deliver large energy savings.

Wastewater treatment separates the incoming sewage stream into treated liquid wastewater effluent and a semi-solid sludge with a high energy potential. After this separation, municipal plants deal with sludge in a number of ways.[17] It may be partially dewatered, which can use a significant amount of electricity if a centrifuge, rotary drum, or belt press is used. (Smaller facilities producing lower quantities of sludge often thicken sludge via the use of gravity in settling tanks.[18]) The sludge may then undergo stabilisation (i.e., speeding up of decomposition) via aerobic digestion (an electricity-intensive process) or anaerobic digestion (which can produce energy – see Chapter 8).[19] It may then be dewatered further, again by centrifuge (also electricity intensive), or in the case of smaller facilities, in reed beds or lagoons.[20] Some sludge is composted, which produces a nutrient-rich soil amendment. Other sludge is heat-dried and pelletized, or incinerated, which use large amounts of natural gas and/or biogas (see Chapter 8). Sufficiently stabilized sludge that meets relevant standards, now called *biosolids*, may be used as interim cover at landfills or applied to land as a soil amendment. If the sludge has been incinerated, the resulting ash is typically landfilled or recycled (e.g., in cement manufacturing). [21]

Wastewater treatment separates a sludge with a high energy potential.

2.5 Water and Wastewater Pumping

Pumps move water from its source (lakes, rivers or aquifers) to and through drinking water treatment facilities, then distribute drinking water through pipes to homes and businesses. Pumps may also help return collected wastewater to treatment facilities and then back to surface waters. They may be housed in dedicated pumping facilities or within water and wastewater treatment facilities where they push water and wastewater through various treatment processes.



Motor and pump at a pumping station in the Region of Peel

Source: *A Pump Efficiency Assessment and Awareness Pilot Study* (Hydratek, 2013).

Pumps use a considerable amount of energy, primarily electricity (see Figure 2.4). Dedicated water and wastewater pumping facilities together account for at least 30% of energy use in the municipal water cycle in Ontario (see Figure 2.4 and section 3.1.2). Pump energy use is affected by variables in addition to pump efficiency, such as water volume, change in elevation, desired water pressure and friction in the piping network. Pumping energy use is typically greater for drinking water (typically going up, against gravity) than for wastewater pumping (typically going down, with gravity) (see Figure 2.4). For similar reasons, pumping groundwater is more energy intensive than surface water.

Pumps must work much harder (and use more energy) than necessary when they have to pump extra water or wastewater. This happens when treated drinking water leaks out of the drinking water system, or stormwater infiltrates into the wastewater system. A surprisingly large amount of treated water never reaches customers.[22] A majority of these losses may be due to leakage, as well as other non-metered use such as maintenance flushing, fire fighting, and freeze-up protection.[23] Similarly, infiltration and inflow into sewage pipes is a big issue for wastewater pumping and treatment.

According to our survey (see Textbox 1.4.1), drinking water leakage rates are as high as 40% in some municipalities. It can be difficult to separate leakage from other unmetered uses such as firefighting. Infiltration rates into wastewater systems are also not widely known, but available data suggests they range from 5%-30%.[24] High leakage and infiltration rates are a symptom of underinvestment in both energy efficiency and infrastructure maintenance. Leaks result in more water needing to be treated and pumped to compensate for the losses while still providing acceptable water pressure to more distant customers. Perhaps surprisingly, the fraction of energy wasted is typically 30-80% higher than the percentage of water lost through leakage (e.g., a 20% leakage rate might mean an increase in pump energy use of 26-36%), as pumps need to work harder to maintain desired pressure levels.[25] The increased workload may shorten the lifetime of pumps, and increased upstream pipe pressure may trigger other leaks.

High leakage and infiltration rates are a symptom of underinvestment in both energy efficiency and infrastructure maintenance.

As shown in Textbox 2.5.1, leakage and infiltration can be reduced in a variety of ways, including pressure management, leakage detection and replacement of infrastructure.[26] Zero leakage may not be feasible, but leading jurisdictions, like Israel, Japan and Denmark, have achieved water loss rates as low as 6%.[27]

2.5.1 As Water Leaks, so Does Energy

Across the province, 10% of potable water is reported to be lost from the distribution system. This may be an underestimate, as an additional 13% is reported as "sector of use unknown".[28] Leakage rates reported by Ontario municipalities in the ECO survey ranged from 0% to 40%, with slightly more than half of the municipalities reporting leak rates below 10% (see Figure 2.6).

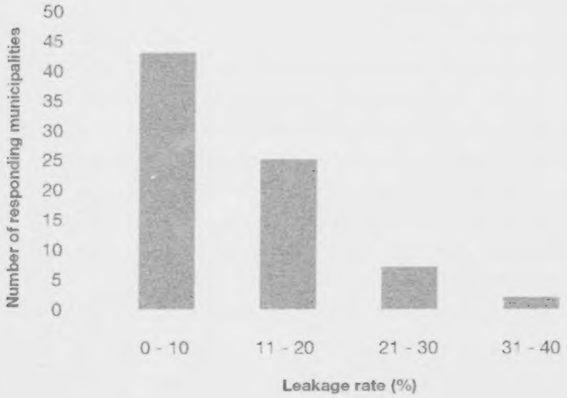


Figure 2.6. Ontario municipal water system leakage rates

Source: ECO 2017 Municipal Water-Energy Efficiency Survey (see Textbox 1.4.1, and Appendix A)

Why do Some Systems Leak so Much?

There are many causes for leaks. Variations in soil type, pipe construction material (such as polybutylene piping),[29] method of installation, and location all have a role to play. Pipes also deteriorate with age, leading to higher water losses and higher energy loss due to friction.[30] Pipe breaks differ from leaks and require immediate attention, as a large amount of water can be lost in a short time.[31]

What can be Done to Reduce Leakage?

It is not possible to eliminate all leakage, but it can be substantially reduced. Strategies for reducing leak rates include better leak detection, more rapid repair of identified leaks, pressure management (not over pressurizing water), and regular infrastructure maintenance and rehabilitation to keep pipes in good working order. New technologies such as *smart balls* that can travel through the distribution system and assess pipe conditions before major leaks occur provide the promise of better targeting infrastructure spending on pipe maintenance and replacement.

Sixty percent of respondents to the ECO survey[32] indicated that they are taking steps to deal with leakage. The City of Kawartha Lakes is a good example.[33] Kawartha Lakes manages 21 separate water distribution systems, and focused its leak management efforts on areas with high rates or high volumes of water loss. The city divided the water distribution system into smaller segments that are individually monitored for water flow and pressure, making it easy to identify anomalies, such as leaks. Their leak detection program has shown that by reducing water pressure by 10%, 15% of water loss can be avoided. With the help of acoustic leak detection technology, the program found and repaired leaks equating to approximately 30 m^3/hr of reduced water loss, an annual reduction of about 262,000 m^3. This represents a significant energy reduction.

The International Water Association/American Water and Wastewater Association Water Audit Method is being adopted by many Ontario municipalities, such as the City of Guelph,[34] Region of Peel[35] and the Region of Halton.[36] It enables a municipality to estimate unavoidable losses, and determine if its avoidable losses are higher than average. If so, this would suggest that the system is a good candidate for more focused efforts on reducing the leak rate.[37] Using this method, between 2006 and 2014 the City of Guelph was able to save 3.7 million cubic metres of water and over $300,000 in electricity costs to treat and pump that water.[38]

Energy savings can also be achieved from improved pumping performance, either by improving the efficiency of individual pumps (e.g., by installing variable speed motors or smaller, more efficient, pumps), or how they work together as a system (see Textbox 2.6.1). Pumps can also achieve large cost savings and greenhouse gas reductions by scheduling flexible loads when electricity is off-peak, cheaper, and essentially emissions-free.

2.6 Load Shifting: Storing Energy Within the Water Cycle and Reducing Emissions

Balancing the Electrical Grid

It is not only the amount of energy used in the water cycle that matters; time of use is important too, especially for electricity.

For operators of Ontario's electrical grid, one of the largest challenges is to constantly balance huge swings in electrical supply and demand. When demand is low (typically at night and on weekends, especially when the weather is not too hot or too cold), Ontario's electric grid must often pay for low-emission power it does not need.[39] When demand is high (e.g., on hot or cold weekdays), gas-fired generation ramps up, creating greenhouse gas emissions (see Figure 2.7). These huge swings add substantial cost to the electric system, as well as greenhouse gas emissions.

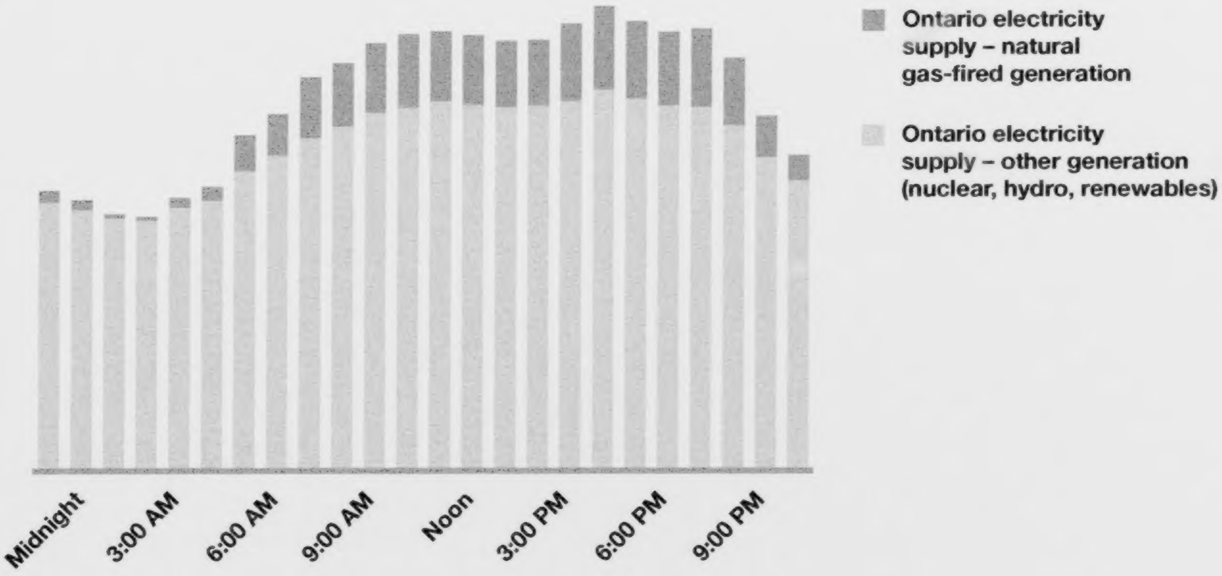


Figure 2.7. Hourly pattern of Ontario electricity supply (hot summer day, conceptual)

Municipal water/wastewater systems are major electricity consumers that could adjust the timing of some of their electricity use to dampen these swings. This is known as *load shifting*. In effect, the water system can serve as a virtual battery, helping the electricity grid run as cleanly and as cheaply as possible.

Load Shifting Opportunities in the Water Cycle

The largest opportunity for load shifting within the water cycle is water pumping. Almost all water systems have intermediate water storage, e.g., elevated water tanks. By adjusting water storage levels, the operators of these systems have some flexibility in when to operate the electricity-intensive pumps that move water into and out of their reservoirs, and could choose to minimize pumping during electrical system peaks. For example, California water agencies are able to shift enough load to reduce their electricity use by about one-quarter during weekday afternoons when electricity demand peaks.[40]

The water system can serve as a virtual battery.

Another opportunity for load shifting is aeration, the process that typically consumes the most energy in wastewater treatment plants. By over-oxygenating wastewater during off-peak hours, some operators could turn off or reduce aeration during the electrical peak.[41]

A third opportunity exists for wastewater plants that capture biogas to generate electricity (see Chapter 8). These plants could store some biogas during off-peak hours, and use it to self-generate more electricity during peak hours when electricity prices are high. The City of Barrie is investigating this option.

The ECO has long called for sharper differences between on- and off-peak electrical pricing.

Are Water System Operators Incented to Load Shift?

Water operators would be expected to load shift if they received appropriate price signals from the electricity system operator. However, the financial savings to water/wastewater system operators from load shifting are currently modest, because there is little difference between the price they are charged for electricity on- and off-peak. A high percentage of electricity costs from all forms of generation have been loaded into the Global Adjustment, which does not vary depending on the time of electricity use (see Figure 2.8). As a consequence, some municipalities are aware of, but not using, opportunities for load shifting in their water systems.[42] The ECO has long called for sharper differences between on- and off-peak electrical pricing.[43]

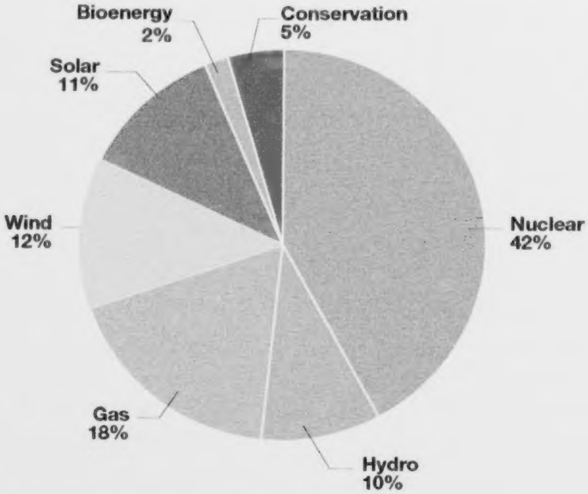


Figure 2.8. Estimated cost components of the Global Adjustment, by electricity resource (2015)

Source: Ontario Energy Board; Independent Electricity System Operator[44]

Load shifting away from hours of peak system demand may soon become more financially attractive for water system operators. Due to a recent regulatory change, more water and wastewater operations will be eligible as of July 1, 2017 to participate in the Industrial Conservation Initiative.[45] Under this program, eligible customers that reduce consumption during the five highest system-wide peak hours over the course of the year are rewarded with lower Global Adjustment costs (this is sometimes called "load shedding").[46] In practice, participants typically reduce load for more than five hours because the peak times are not known in advance. However, this program will likely drive load shifting only on 10-20 days throughout the year, and thus does not capture the full potential for load shifting in the water system.

Ontario's cap and trade system has also embedded a small carbon cost within the wholesale on-peak electricity price signal (an additional cost of less than one cent per kWh when natural gas is on the margin, currently about one-third of the time). This may provide a small additional incentive for shifting electricity use to off-peak hours.

2.6.1 A Load Shifting Success Story: The Transmission Operations Optimizer

The Transmission Operations Optimizer (TOO) at the City of Toronto is a recent project that combines load shifting and energy efficiency to deliver financial, energy, and environmental benefits for a complex water system.[47] The system is scalable to both large and small municipalities.

The TOO is used to manage a drinking water supply network for Toronto and York Region that includes four treatment plants, 30 pumping stations with 150 pumps, and 30 intermediate storage tanks or reservoirs. This complexity means that there is a vast number of ways to operate the network and meet water demand, each with their own energy use, cost and GHG profile.

The integrated TOO control system must predict and meet customer water demand at acceptable pressure levels at all times, taking into account equipment outages, maximum storage capacities and equipment flow rates.

Working within these constraints, the TOO system optimizes the operations of this entire water supply network to minimize overall electricity costs.[48] It looks for two kinds of savings:

- Reducing the cost per unit of energy used, by shifting the timing of electricity use to make use of cheaper off-peak electricity rates (see Figure 2.9); and
- Reducing energy use, for example, by running pumps in their most efficient operating range, and avoiding energy waste due to overfilling storage reservoirs and overpressurizing water (see Figure 2.10).

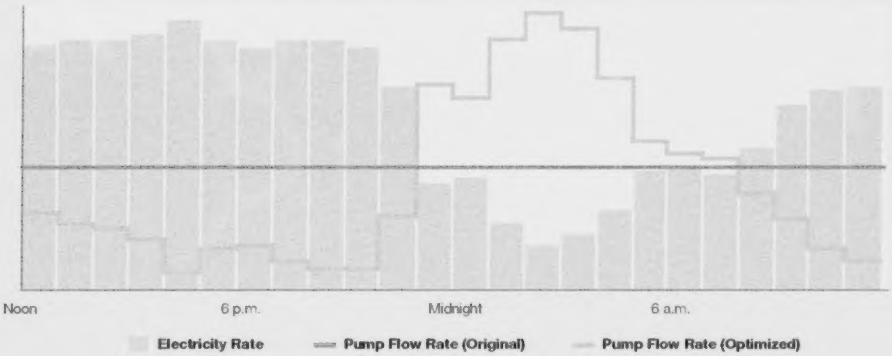


Figure 2.9. Optimizing timing of water pumping to reduce energy costs

Note: Graph is conceptual and does not show actual operating data.

Source: Adapted from IBI Group and City of Toronto, *Smart Operations: City of Toronto's Water Transmission Optimization* (presentation to World Water-Tech North America, October 2016).

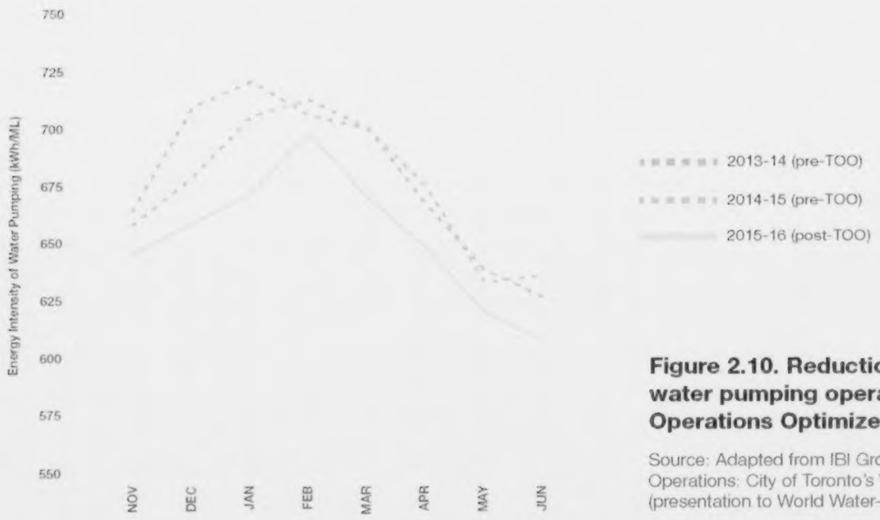


Figure 2.10. Reduction in energy intensity of water pumping operations from Transmission Operations Optimizer

Source: Adapted from IBI Group and City of Toronto, Smart Operations: City of Toronto's Water Transmission Optimization (presentation to World Water-Tech North America, October 2016).

The project is estimated to save approximately 16 million kilowatt-hours annually according to Toronto Hydro, the equivalent of the electricity consumption of about 1,700 homes, and reduce greenhouse gas emissions by 11,244 tonnes of carbon dioxide equivalent. Savings in electricity costs were estimated to be close to $1 million in 2016.[49] The project is expected to pay back its original investment in approximately two years. It was supported through Toronto Hydro's saveONenergy Retrofit Program with a $1.6 million incentive.[50]

Endnotes

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Chapter 3

Making Energy Reporting Work

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Is water system energy reporting worth the cost?

Easy improvements would make it really useful

Abstract

For many municipal governments, water and wastewater systems are their largest energy uses and major sources of greenhouse gas (GHG) emissions. Reporting under Ontario Regulation 397/11 is supposed to identify the potential for energy and GHG improvements, but the process is more of a reporting burden than a useful conservation tool for municipal water systems.

Why? First, O. Reg. 397/11 reporting from water systems unwisely leaves out much of what energy managers need to know, including:

1. energy used in pumping facilities,
2. energy generated on-site, and
3. municipal water use.

Second, O. Reg. 397/11 reporting is slow and poorly analyzed and as a result provides little value as a benchmarking tool. For example, the Ministry of Energy did not release 2014 data until 2017, and even then with no value added. Instead, Ontario should direct municipalities to submit their data via Portfolio Manager, which is an online, free, and user-friendly energy and GHG tracking tool. This tool enables municipalities to upload up-to-date energy use information and provides immediate analysis and feedback. It would help municipalities develop a meaningful energy and GHG baseline, benchmark against peers, identify savings opportunities, and monitor and verify results of energy efficiency initiatives.

Third, small- and medium-sized municipalities need provincial support to better access and understand energy data.

3.1 Provincial Energy Reporting Requirements for Municipal Water Systems

3.1.1 O. Reg. 397/11: A Boon for Energy Conservation in Ontario's Broader Public Sector?

Though it may seem obvious, it bears repeating: you can't manage what you don't measure. If you're trying to make a change, you need to know your starting point. Start with a baseline, then track progress from that baseline. And comparing your baseline against your peers, a practice known as benchmarking, can help you find the best opportunities. Yet, obvious or not, energy and greenhouse gas (GHG) baselines and benchmarking have not been common practice for small- to medium-sized municipal water and wastewater facilities in Ontario.[1]

In 2012, Ontario took an important step by mandating public energy reporting for over 15,000 broader public sector buildings.[2] Starting with the year 2011, all Ontario municipalities have been required to publicly report their energy use and GHG emissions, and to produce five-year conservation and demand management plans.[3] Facilities that are required to report under Ontario Regulation 397/11 include drinking water and wastewater treatment facilities.

O. Reg. 397/11 has major weaknesses.

The data provided under O. Reg. 397/11 has helped the ECO and many others understand just how energy- and GHG-intensive municipal water systems can be. However, O. Reg. 397/11 has major weaknesses. In addition to improved energy and GHG emissions reporting, discussed below, a third type of data would help improve municipal water system energy efficiency, but is not required under O. Reg. 397/11: water use in municipal and other broader public sector buildings. This topic is examined in Chapter 5, Water Conservation, at section 5.3.

3.1.2 O. Reg. 397/11: Incomplete Energy Reporting

Exemption of Pumping Facilities from Mandatory Reporting

As described in Chapter 2, there are three distinct types of facilities involved in the municipal water cycle: pumping, water treatment and wastewater treatment facilities. In 2015, the Ontario government amended O. Reg. 397/11 to exempt one of these three – drinking water and wastewater pumping stations – from reporting energy consumption and water flow data, extending back to 2012 (see Figure 3.1).[4]

According to the Ministry of Energy, the Ontario Clean Water Agency[5] and comments submitted in response to the Environmental Registry regulation proposal notice #012-3087, the 2015 exemption was adopted in response to complaints from some municipalities about the cost of metering water and wastewater flow rates (i.e., the amount of liquid being pumped) through all pumping stations.[6]

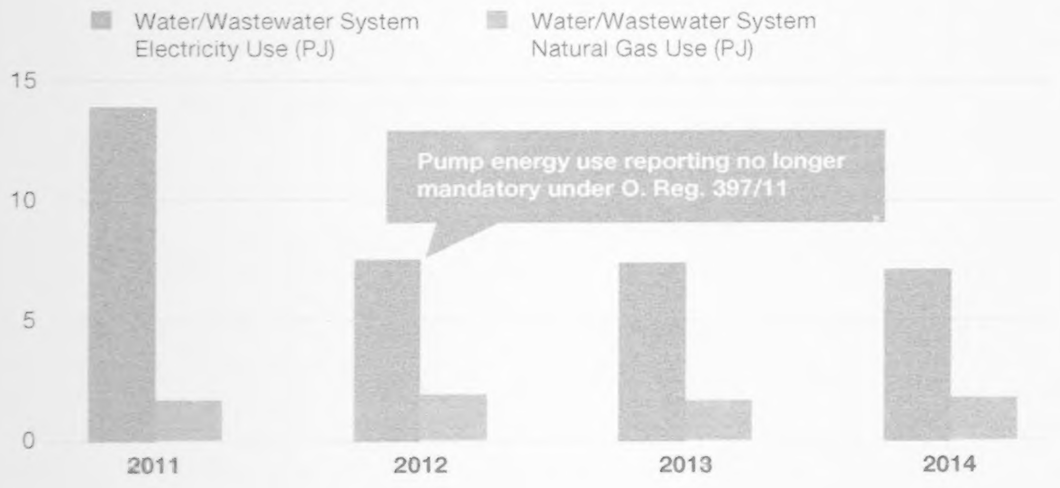
The flow rate of a pumping facility is important for benchmarking because it allows operators to more fairly compare the energy intensity of different pumping stations (i.e., energy used per litre pumped).[7] Also accounting for the pump lift (i.e., pressure differential) would further improve the comparison. For an example of the scale of energy savings possible by optimizing pumping operations see Textbox 2.6.1 (in Chapter 2) on Toronto's Transmission Operations Optimizer. Even without water flow data, reporting the energy use of pumping stations would provide municipalities and the public with useful records of energy use and associated GHG emissions[8] year over year.

> The reporting exemption for pumping stations was short-sighted.

Nevertheless, the 2015 amendment abandoned all reporting requirements for water and wastewater pumping stations. The ECO believes that the reporting exemption for pumping stations was short-sighted. It should be reversed, and those municipalities in need of flow meters should be provided with adequate support.

This exemption had a dramatic effect. Pumping facilities account for at least 30% of Ontario's water system energy use, primarily in the form of electricity (based on reported 2011 pumping energy use data screened for accuracy by the Ministry of Energy, see Chapter 2, Figure 2.4), although estimates range from about 10% (Barrie) to 60% (York Region).[9]

Some municipalities continue to voluntarily report data from their pumping facilities. However, once mandatory reporting was abandoned, the number of pumping stations reporting dropped sharply, from 2,453 in 2011 (representing 61% of water system electricity use), to 1,463 in 2014 (representing 31% of electricity use). Electricity use reported by water systems dropped by almost half (see Figure 3.1). According to the Ministry of Energy, about 46% of the pumping energy use reported in 2011 was inaccurate. As a result, it is unclear how much electricity is actually used by pumping facilities in Ontario, though it is fair to say that it is much higher than what is currently being reported.



Pump energy use reporting no longer mandatory under O. Reg. 397/11

Figure 3.1. Reported provincial drinking water and sewage system energy use in petajoules (2011-2014)

Source: Ministry of Energy, O. Reg. 397/11, raw data (2011-2014).

Energy Produced On-Site

Ontario Regulation 397/11 does not require municipalities to report energy produced and used on-site, only the energy purchased for use.[10] As a result, O. Reg. 397/11 provides misleading energy use data, which is unreliable for benchmarking. For example, a municipal facility with low reported energy use may be operating efficiently, or it may be operating inefficiently but using energy (e.g., methane, solar, heat recovery) produced on-site. Reporting all energy use would allow effective benchmarking. It would also enable facilities using renewable energy to show ratepayers their greener energy profile.

O. Reg. 397/11 provides misleading energy use data.

3.1.3 O. Reg. 397/11: Incomplete GHG Emissions Reporting for Wastewater Facilities

A suite of provincial-level and municipal-level initiatives exist to encourage municipalities to track and lower their GHG emissions.[11] Included among them is O. Reg. 397/11 that, in addition to energy use reporting, provides estimates of related GHG emissions. This provides the only publicly available GHG emissions data set for all of Ontario's municipal wastewater facilities. This information is of great potential value for the many Ontario municipalities that have or are developing climate targets, GHG inventories, and emissions reductions strategies, as well as for Ontario's climate targets as a whole.

It should be noted that other GHG reporting obligations exist at the federal and provincial level. In particular, the federal government provides nation-wide GHG reporting in its National Inventory Report (NIR) submitted annually to the United Nations Framework Convention on Climate Change. As described below, the federal government's assumptions applied to the wastewater treatment sector leave out substantial amounts of process emissions. The GHG emissions estimates in the NIR are in some cases substantiated by large individual facility reporting via the federal Greenhouse Gas Emissions Reporting Program (GHGRP); however, because of its high reporting threshold the GHGRP only mandatorily captures one of Ontario's several hundred wastewater treatment plants (Duffin Creek in Durham). The provincial government also has an individual facility GHG reporting regulation, with a lower reporting threshold; however, it does not require reporting from municipal wastewater treatment facilities. In short, none of these other GHG reporting regulations comprehensively capture GHG emissions from municipal wastewater facilities.

Ontario Regulation 397/11 requires GHG emissions to be calculated using a Ministry of Energy template. However, as described above for energy use, the GHG template only recognizes GHG emissions from purchased energy.[12] This narrow approach shows wastewater facilities to be the largest emitters within the municipal water cycle (see Chapter 2, Figure 2.3), but fails to reflect the full GHG emissions of wastewater facilities.

This narrow approach fails to reflect the full GHG emissions of wastewater.

In addition to the GHG emissions from energy purchases, wastewater treatment facilities produce GHG emissions (specifically methane, nitrous oxide and carbon dioxide) as natural by-products of wastewater treatment processes, none of which are currently reported under O. Reg. 397/11.

Although O. Reg. 397/11 was designed to address public sector building energy use and associated GHG emissions, the GHG emissions it reports should be expanded to include process emissions in order to improve the quality and usefulness of the data set.

This would provide municipalities and the public with a more accurate understanding of the carbon footprints of public facilities. The federal and provincial GHG reporting regulations outlined above should also be improved to better reflect wastewater facility process GHG emissions.

Methane

As the organic matter in wastewater decomposes, it typically releases carbon dioxide and methane. Of the two, methane is a much more potent greenhouse gas, 86 times more damaging over a 20-year period (including climate carbon feedbacks).[13]

Methane is produced under anaerobic conditions (i.e., where oxygen is not present). These conditions may be present, for example, in:

- lagoons,
- septic tanks,
- anaerobic digesters (from which methane may escape due to incomplete combustion and/or leaks) (see Chapter 8 for a discussion of energy production from anaerobic digestion),[14] and
- anaerobic pockets inadvertently created during pumping, settling, and storage.[15]

The escape of unburned methane can be limited with regular maintenance.

Sixty-two thousand tonnes of methane emissions (in CO_2 equivalents) were attributed to wastewater treatment in Ontario according to the most recent federal National Inventory Report.[16] However, this likely underestimates actual emissions. The default method used by the Canadian government to calculate methane emissions from wastewater treatment assumes that only anaerobic systems such as lagoons and septic tanks emit methane, neither of which are used at larger wastewater plants. The potentially substantial methane emissions from other types of wastewater systems are assumed to be negligible.[17] This means that the NIR assumes that there are no methane emissions from larger treatment plants.[18]

In contrast, the IPCC estimates that between 0-10% of the maximum methane production potential of incoming wastewater at larger plants may be emitted during wastewater treatment at centralized treatment plants.[19] For this reason, jurisdictions such as Denmark now include estimated methane emissions from centralized plants (i.e., without septic tanks and lagoons) in their National Inventory Reports.[20]

Using the same methane emission factors as in the Denmark report, the ECO estimated the potential unreported methane emissions from an Ontario wastewater treatment facility serving one million people.[21] We calculated that the unreported methane under three alternative scenarios, including wastewater treatment with,

1. anaerobic digestion and energy recovery;
2. anaerobic digestion with flaring; and
3. no anaerobic digestion (see Figure 3.2).[22]

Depending on the scenario, inclusion of the unreported methane could increase the facility's GHG emissions reported under O. Reg. 397/11 by 3-9% (or 7-22% using a 20-year time horizon for global warming potentials).

As illustrated in Figure 3.2, the addition of anaerobic digestion to wastewater treatment facilities has the potential to increase methane emissions. Nevertheless, the GHG benefits of biogas energy recovery greatly exceed the impacts from the additional methane emissions. It is important to ensure that any on-site methane emissions are regularly monitored, especially where anaerobic digesters are present. Using one Canadian estimate for methane losses via accidental venting at an anaerobic digester (5% of methane generated), the impact of unreported methane could be as high as 23% of reported emissions.[23]

Ideally, O. Reg. 397/11 would require site-specific measurements of process-related methane emissions. However, many facilities may not have the resources to undertake such measurements. As such, the province should also provide default emissions assumptions, ideally based on:

1. a representative sample of site-specific measurements from Ontario wastewater treatment facilities, or
2. the most current peer-reviewed science that would be representative of conditions in Ontario wastewater treatment facilities.

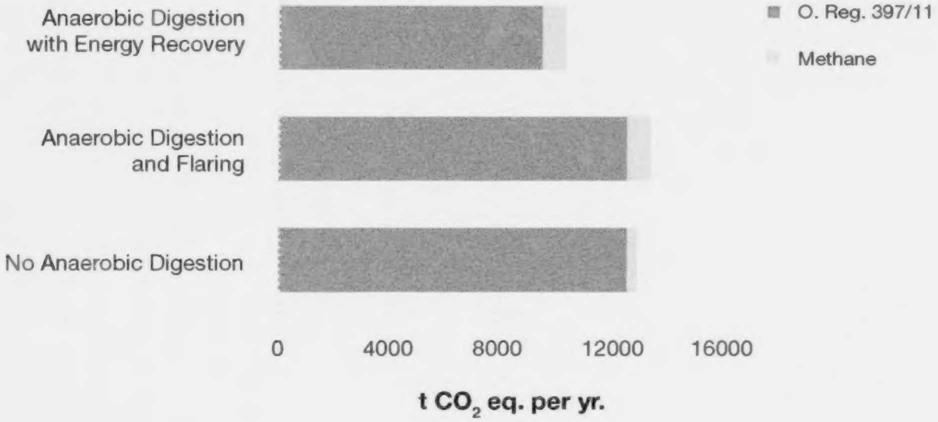


Figure 3.2. An example of the wastewater GHG emissions produced on-site that are not reported under O. Reg. 397/11 (using a 100-year time horizon and IPCC AR5 global warming potentials)

Source: Figure created by ECO using data described in the endnote.[24]

Nitrous Oxide

Nitrous oxide, a greenhouse gas up to 300 times more potent than carbon dioxide,[25] is produced at wastewater treatment facilities from processes used to reduce ammonia levels in wastewater (i.e., nitrification and denitrification).[26] However, without this process, the nitrogen levels in the effluent would be much higher, resulting in increased off-site emissions. Ammonia removal helps protect the health of the receiving water body, and is required by regulation at many sites.[27]

Certain ammonia removal practices at wastewater treatment facilities are known to reduce on-site nitrous oxide emissions.[28] This suggests that they have the potential to reduce overall emissions, including those generated off-site from the treated effluent. Unfortunately, the method used in Canada's NIR to estimate nitrous oxide emissions does not take this into account.[29]

Municipal wastewater treatment facilities should be required to publicly report their nitrous oxide emissions via O. Reg. 397/11, based on the emission factors supported by the most current science. If properly structured, publicly reporting nitrous oxide emissions via O. Reg. 397/11 has the potential to provide incentives to adopt practices and technologies to reduce these emissions both on-site (by improving treatment processes) and off-site (by reducing the nitrogen content of the effluent). For example, wastewater treatment facilities could increase their use of ammonia capture technologies that produce a fertilizer substitute,[30] which may decrease nitrous oxide emissions and also displace emissions from conventional fertilizer production.

Carbon Dioxide

Substantial amounts of carbon dioxide are generated from the biological decomposition of organic matter in wastewater treatment facilities. Combustion of biogas (methane) from anaerobic digesters also generates carbon dioxide (whether the biogas is flared or used for heating or combined heat and power generation).

Canada treats these carbon dioxide emissions as "carbon neutral,"[31] based on an assumption that all of the carbon dioxide emitted from wastewater has recently been sequestered from the atmosphere by plant growth. However, this assumption is incorrect. Wastewater treatment processes generate a considerable amount of carbon dioxide from fossil fuel-based substances, such as soaps and detergents.[32] Correctly classifying these carbon dioxide emissions as fossil-based may increase a facility's GHG emissions by 13% to 23%.[33]

Ontario should stop ignoring the GHG emissions that can come from wastewater treatment processes. O. Reg. 397/11 GHG reporting for water systems will be misleadingly low until it includes such GHG emissions.

> Ontario should stop ignoring the GHG emissions that can come from wastewater treatment processes.

3.2 Making Energy Reporting More Valuable

Ontario municipalities argue that the cumulative weight of provincial reporting requirements is burdensome, yet provides limited value.[34] In this context, it matters: do municipalities benefit from the reporting requirements of O. Reg. 397/11?

At present, the Ministry of Energy requests data that is two years old, and then publishes the aggregated data many months later (e.g., 2014 data was published in January 2017). The final product available for municipalities is over two years old and of limited use for benchmarking. As a result, municipalities do not know if their plant energy performance is good, better, best or worst.

Portfolio Manager

A much better solution is at hand. ENERGY STAR Portfolio Manager is a widely used tool developed by the United States Environmental Protection Agency (U.S. EPA), which allows building and facility managers to track energy and water consumption and GHGs. It provides a user-friendly reporting platform and immediate analysis of the submitted data. Portfolio Manager is also specifically designed to enable effective benchmarking between building types, including wastewater facilities.

The U.S. EPA advises water and wastewater facilities to use Portfolio Manager to track and (in the case of wastewater facilities) benchmark their energy use and GHG emissions.[35] Ontario water systems have the same needs.

The limited data available shows a broad range of energy intensities per megalitre of water treated across Ontario's water systems (see Figure 3.3 for water treatment plants and Figure 3.4 for sewage plants).

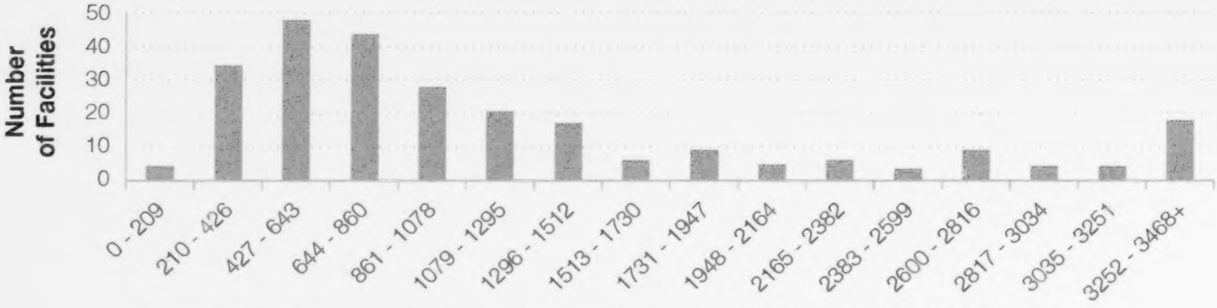


Figure 3.3. Energy intensities of Ontario water treatment facilities in 2011 in equivalent kilowatt hours per megalitre

Source: Ministry of Energy, O. Reg. 397/11, 2011 normalized data.

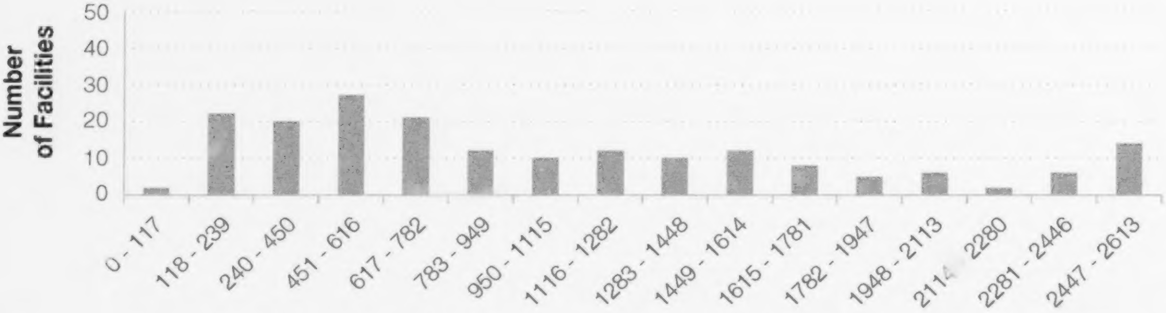


Figure 3.4. Energy intensities of Ontario sewage treatment facilities in 2011 in equivalent kilowatt hours per megalitre

Source: Ministry of Energy, O. Reg. 397/11, 2011 normalized data.

However, higher energy intensities do not necessarily indicate lower efficiencies. Meaningful comparisons must take into account differences in source water or wastewater characteristics and in drinking water and wastewater effluent treatment requirements. For example, in the U.S., Portfolio Manager generates an ENERGY STAR score for wastewater plants that accounts, and corrects, for variations in energy use due to a number of key variables, such as the quality of the influent wastewater, the degree of treatment, and climatic conditions. It could do the same for Ontario.

Portfolio Manager is already widely used in Canada. As of January 2016, approximately 13,500 buildings in Canada were voluntarily using the tool, representing approximately 14% of Canada's commercial floor space.[36] Ontario's energy and water reporting and benchmarking regulation, filed on February 6, 2017, will require large private sector buildings to use Portfolio Manager for monthly energy use and water consumption reporting.[37]

Portfolio Manager would provide a one-stop shop for a municipality's internal energy management work as well as for provincial energy use, water consumption, and GHG emissions reporting. This could make conservation more convenient and effective, and could greatly facilitate energy audits (see Textbox 3.2.1).

Portfolio Manager could make conservation more convenient and effective.

3.2.1 Moving Toward Best Practices: Energy Audits and Optimization

Best practice dictates that water/wastewater energy savings initiatives should begin with an audit.[38] An energy audit typically collects much the same data as Portfolio Manager, such as:

- water/wastewater flow rates,
- water/wastewater characteristics,
- final effluent or drinking water quality,
- treatment processes, and
- energy use by major equipment, if sub-metering permits.

Based on an analysis of this data (as well as regulatory requirements and electrical schematics), a typical energy audit report will identify energy efficiency opportunities (operational and capital), potential financial and energy savings, capital cost estimates, anticipated payback periods, and will then make recommendations on how to proceed. The Ontario Clean Water Agency undertakes energy audits for small- to medium-sized water and wastewater facilities across Ontario on a fee-for-service basis. According to the agency, energy audits typically identify low-cost operational savings of around 15%.

Plant optimization is a slightly different approach to improving plant efficiency. It is similar to an energy audit in that it aims to achieve the lowest cost and least energy intensive approach to meeting regulatory requirements and service standards. However, plant optimization is more comprehensive than an energy audit; in addition to analyzing energy use, it also assesses other aspects of plant operations such as management practices and operator training.[39] Optimization can produce significant savings. A wastewater optimization pilot program in Haldimand County, for example, allowed a deferral of more than $10 million in forecasted capital infrastructure costs.[40] Communities under 100,000 in Ontario are eligible for provincial funding for optimization. [41]

3.3 From Benchmarking to Action

Portfolio Manager would help municipalities identify facilities that have higher energy intensities than their peers. However, this does not necessarily indicate inefficiency. Further investigation would be required to know why some facilities consume more energy, and what to do about it. Larger municipalities can manage these investigations, but they can be very challenging for smaller ones, especially outside the Greater Golden Horseshoe.

The province could help. About 25% of the municipal respondents to the ECO survey would like to have provincial financial and training assistance to better collect and analyse detailed energy use data. For example, many lack **funds for sub-metering** individual pieces of equipment (e.g., pumps) – a similar reason given in 2015 for exempting pumping stations from reporting. Without sub-metering, municipalities can get overall data from their utility bills, but not in enough detail to identify opportunities to save energy. Currently, funding programs for sub-metering do exist, but due to burdensome administrative requirements, have had low uptake.[42] Targeted funding, structured as simple rebates, for sub-metering would enable more municipalities to understand how energy and water are used in their facilities and where opportunities for savings exist.

Energy efficiency should be a standard part of water system operator training.

Another option would be more **support for energy audits**, which identify and prioritize energy saving opportunities (see Textbox 3.2.1). Funding is available from the Independent Electricity System Operator for up to 50% of energy audit costs[43] (though the program is tailored towards commercial and industrial buildings rather than for water and wastewater facilities) plus some follow up measures,[44] but half of small to medium-sized municipalities believe they cannot afford, or are otherwise unwilling, to pay for their share of such costs.[45] This likely means that significant energy savings from municipal water systems are currently being left on the table.

Water systems of all sizes could benefit from **faster access to utility data that includes time of use**. Billing meters for electricity and gas typically collect energy-use data in short intervals (e.g., every hour or more frequently), but this information is often not available to customers. More frequent data is particularly important for electricity use, because the cost of electricity also varies with time.

Finally, **energy efficiency** should be a standard part of water system **operator training**. The province sets detailed training and licensing requirements for water and wastewater operators, but none of them cover energy efficiency.[46] As a result, energy efficiency is not a focus for many plant operators, unless it is promoted within their organization.

Good quality data can enable informed cost-benefit decisions about what type of approach will produce the most energy savings for the least money. Sometimes, much can be done through operational adjustments. However, energy savings may require capital investment for equipment upgrades. All too often, such capital is not provided. Chapter 4 looks at whether asset management planning will help.

3.4 ECO Recommendations

Recommendation: The Ministry of Energy should make O. Reg. 397/11 energy reporting for municipal water and wastewater systems more accurate and useful by including:

- ***pumping facilities;***
- ***energy produced on-site (e.g., biogas, solar), not just purchased energy; and***
- ***methane, nitrous oxide, and fossil-source carbon dioxide emissions from wastewater.***

Recommendation: The Ministry of Energy should enable or require municipal water and wastewater systems to report under O. Reg. 397/11 through Portfolio Manager and require municipalities to report their annual energy use on a timelier basis.

Recommendation: The Ministry of the Environment and Climate Change should include energy efficiency in the training and licencing requirements for drinking water and wastewater system operators.

Endnotes

1. By developing a baseline of energy use and GHG emissions, a facility's operator/manager can then compare that baseline to future usage and emissions, as well as to the energy use and emissions of other facilities. These comparisons can be used to identify an unusually large energy and GHG footprint. Potential energy savings may be sufficient to drive efficiencies. Making the energy and emission data public may drive further action due to potential pressure from citizens seeking reduced operating costs and environmental impacts from publicly-funded facilities. Any initiatives taken to reduce that footprint can then be monitored to verify actual reductions.

2. *Energy Conservation and Demand Management*, O Reg 397/11 (filed 23 August 2011; came into effect 1 January 2012), made under the *Green Energy Act, 2009*, SO 2009, c 12, Sched A..

3. See Environmental Commissioner of Ontario, "4.0 Public Buildings" in Conservation: *Let's Get Serious*, Annual Energy Conservation Progress Report- 2015/2016 (Toronto: ECO, 2016) at 59.

4. Environmental Registry Regulation Decision Notice #012-3087, *Regulatory Amendments to O. Reg. 397/11 Energy Conservation and Demand Management Plans to streamline the reporting process for public agencies under the regulation and improve data quality* (1 June 2016).

5. An Ontario Crown agency, mandated to provide affordable water and wastewater operation services (including energy efficiency services) for Ontario municipalities.

6. Stakeholder meetings, November 2016 and January 2017.

7. The alternative of comparing pumping station energy use per population-served (i.e., energy used per person served) would not allow for a fair comparison due to potential variations in a service area's consumer base, for example, if customers include heavy users like small industry.

8. See the next section for an explanation as to how GHG emissions are calculated.

9. York is a special case, as the majority of treatment of its drinking water and its wastewater is done in other municipalities, so pumping share of energy use is unusually high. Niagara Region also undertakes a relatively high share of water pumping.

10. Municipalities are supposed to report energy produced from "renewable energy generation facilities" in the conservation plans required on a five-year basis under O Reg 397/11; few municipalities interpret this to include the use of biogas.

11. For example, the Ontario Government's proposed land use planning changes for the Greater Golden Horseshoe. See: Municipal Affairs and Housing, *Shaping Land Use in the Greater Golden Horseshoe* (Toronto: MAH, May 2016) at 16; "Partners for Climate Protection Program", updated 1 April 2017, online: Federation of Canadian Municipalities <www.fcm.ca/home/programs/partners-for-climate-protection.htm>.

12. Ontario Ministry of Energy, *A Guide for Public Agencies on Completing the Energy Consumption and Greenhouse Gas Emissions Template* (Toronto: MENG, 15 April 2013) at 10.

13. IPCC. 2013. Climate Change 2013: The Physical Science Basis. Contribution of Working Group I to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change. Chapter 8. Anthropogenic and Natural Radiative Forcing, at 714.

14. One Canadian study assumes venting and incomplete combustion losses of 5%. See: Sahely et al, "Comparison of on-site and upstream greenhouse gas emissions from Canadian municipal wastewater treatment facilities" (2006) 5 J Environ Eng Sci 405 at 409; This assumption is greater than a Danish study's 1.3% estimate. See: Marianne Thomsen, "Wastewater Treatment and Discharge" (2016) No.193 Danish Centre for Environment and Energy at 18. *Contra*, an IPCC background paper measured 10% losses in some U.K. facilities. See: Hobson, "CH4 and N2O emissions from waste water handling" (n.d.) Background Paper.

15. IPCC. 2006. 2006 IPCC Guidelines for National Greenhouse Gas Inventories. Chapter 6. Wastewater Treatment and Discharge, at 6.8 and 6.13; A recent Danish study, citing Johansen (2013), claimed methane emissions of $3*10^{-4}$ kg CH_4 per kg COD from the pumping and storage of digested sludge. A higher estimate of $7.5*10^{-4}$ kg CH_4 per kg COD (or $1.1*10^{-3}$ kg CH_4 per kg BOD_5) was provided for emissions from the sewer, as well as from mechanical and biological treatment processes at the plant. See: Marianne Thomsen, "Wastewater Treatment and Discharge" (2016) No.193 Danish Centre for Environment and Energy at 17.

16. Environment and Climate Change Canada, *National Inventory Report 1990-2015: Greenhouse Gas Sources and Sinks in Canada*, Part 3 (Ottawa: ECCC, 2017) at 59.

17. The Canadian accounting method includes CH4 emissions from anaerobic treatment systems (i.e., septic tanks and lagoons), but discounts all CH4 emissions from aerobic treatment systems (i.e., large wastewater facilities). See: Environment and Climate Change Canada, *National Inventory Report 1990-2014: Greenhouse Gas Sources and Sinks in Canada*, Part 1 (Ottawa: ECCC, 2016) at 182.

18. IPCC. 2006. 2006 IPCC Guidelines for National Greenhouse Gas Inventories. Chapter 6. Wastewater Treatment and Discharge, at 6.13; Environment and Climate Change Canada, *National Inventory Report 1990-2014: Greenhouse Gas Sources and Sinks in Canada*, Part 1 (Ottawa: ECCC, 2016) at 42.

19. For a poorly managed, overloaded system, the range reaches 20-40%. See: IPCC. 2006. 2006 IPCC Guidelines for National Greenhouse Gas Inventories. Chapter 6. Wastewater Treatment and Discharge, at 6.13.

20. Danish Government, Denmark's National Inventory Report 2015 and 2016, Emission Inventories 1990-2014 - *Submitted under the United Nations Framework Convention on Climate Change and the Kyoto Protocol* by Ole-Kenneth Nielsen et al (Aarhus University, Danish Centre for Environment and Energy, 17 June 2016).

21. Methane emission estimates are based on assumptions in Thomsen (2016).

22. This calculation is based on IPCC AR5 reporting guidelines that assume methane has a global warming potential of 86 over a 20-year period. Canada's emissions inventory has not yet updated its methane global warming potential from that specified in the IPCC AR4 (25). See: Environmental Commissioner of Ontario, "3.2 Short-Lived Climate Forcers" in *Facing Climate Change: Greenhouse Gas Progress Report 2016*, (Toronto: ECO, 2016).

23. The increase would be 59% using a 20-year time horizon for the global warming potential. See: Sahely et al, "Comparison of on-site and upstream greenhouse gas emissions from Canadian municipal wastewater treatment facilities" (2006) 5 J Environ Eng Sci 405 at 409.

24. The following inputs were used to generate Figure 3.2:

    (1) IPCC AR5 global warming potentials with a 100-year time horizon;

    (2) confidential data on energy use, annual wastewater input, BOD_5, biogas production, flaring and energy recovery from a large wastewater treatment facility in Ontario;

    (3) the CH_4 emission factor for a conventional wastewater treatment facility. See: Marianne Thomsen, "Wastewater Treatment and

Discharge" (2016) No.193 Danish Centre for Environment and Energy at 17 (0.3 g CH_4/kg COD CH_4 emission estimate for pumping and storage of digested sludge);

(4) emission factors for fossil fuels and electricity production from Ontario. See: Environment and Climate Change Canada, *National Inventory Report 1990-2014: Greenhouse Gas Sources and Sinks in Canada*, Part 3 (Ottawa: EC, 2016) at 94;

(5) the density of methane at 25 degrees Celsius (656 g/m3). See: "Methane" online: Gas Encyclopedia <encyclopedia.airliquide.com/>;

(6) the BOD /COD methane conversion factor of 1.47 used in the NIR. See: Environment and Climate Change Canada, *National Inventory Report 1990-2014: Greenhouse Gas Sources and Sinks in Canada*, Part 1 (Ottawa: ECCC, 2016) at 182; and

(7) the 65% methane content of biogas from wastewater treatment facilities (based on a range of 63% to 67%). See: International Energy Agency Bioenergy, *Nutrient Recovery by Biogas Digestate Processing* by Bernhard Drosg et al (IEA Bioenergy, 2015) at 9.

25. IPCC. 2013. Climate Change 2013: The Physical Science Basis. Contribution of Working Group I to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change. Chapter 8. Anthropogenic and Natural Radiative Forcing, at 714.

26. IPCC. 2006. 2006 IPCC Guidelines for National Greenhouse Gas Inventories. Chapter 6. Wastewater Treatment and Discharge, at 6.26.

27. Some facilities voluntary denitrify beyond regulatory requirements.

28. See for example: Yingyu Law et al, "Nitrous Oxide Emissions from Wastewater Treatment Processes" (2012) 367 Philosophical Transactions of the Royal Society B 1265; Jeffrey Foley et al, "Nitrous Oxide Generation in Full-Scale Biological Nutrient Removal Wastewater Treatment Plants" (2010) 44:3 Water Research 831.

29. Environment and Climate Change Canada, *National Inventory Report 1990-2014: Greenhouse Gas Sources and Sinks in Canada*, Part 2 (Ottawa: ECCC, 2016) at 163.

30. International Energy Agency Bioenergy, *Nutrient Recovery by Biogas Digestate Processing* by Bernhard Drosg et al (IEA Bioenergy, 2015) at 22-24.

31. M.R.J. Doorn et al, "Wastewater treatment and discharge" in *2006 IPCC Guidelines for National Greenhouse Gas Inventories*, (IPCC, 2006); Environment and Climate Change Canada, *National Inventory Report 1990-2014: Greenhouse Gas Sources and Sinks in Canada*, Part 1 (Ottawa: ECCC, 2016) at 180.

32. Linda Y. Tseng et al, "Identification of Preferential Paths of Fossil Carbon within Water Resource Recovery Facilities via Radiocarbon Analysis" (2016) 50 Environmental Science & Technology 12166 at 12176; Yingyu Law et al, "Fossil organic carbon in wastewater and its fate in treatment plants" (2013) 47 Water Research 5270 at 5275 and 5279.

33. As this science is relatively new, the Ministry of Energy should evaluate it further before determining if and how to incorporate it in O Reg 397/11 wastewater GHG emissions calculations. These percentage estimates are based on the IPCC 2006 calculation methodology. See: Linda Y. Tseng et al, "Identification of Preferential Paths of Fossil Carbon within Water Resource Recovery Facilities via Radiocarbon Analysis" (2016) 50 Environmental Science & Technology 12166 at 12176.

34. Association of Municipal Managers, Clerks and Treasurers of Ontario, *Bearing the Burden, an overview of municipal reporting to the province* (AMCTO, 2017).

35. United States Environmental Protection Agency, *Energy Efficiency in Water and Wastewater Facilities* (US EPA, 2013) at 10.

36. Integral Group and Canada Green Building Council, *Advanced Energy Reporting and Benchmarking in Canada, a guide for provinces and local governments* by David Ramslie (IG & CGBC, 2016) at 18.

37. *Reporting of Energy Consumption and Water Use*, O Reg 20/17, made under the *Green Energy Act, 2009*, SO 2009, c 12, Sched A.

38. United States Environmental Protection Agency, *Energy Efficiency in Water and Wastewater Facilities, a Guide to Developing and Implementing Greenhouse Gas Reduction Programs* (US EPA, 2013) Figure 2.

39. Ontario Ministry of the Environment, *Optimization Guidance Manual for Drinking Water Systems 2014* (Toronto: MOE, 2014) at Chapter 3; Ontario Ministry of the Environment, *Optimization Guidance Manual for Sewage Works 2010* (Toronto: MOE, 2010).

40. "Wastewater Optimization", online: Grand River Conservation Authority <www.grandriver.ca/en/our-watershed/Wastewater-optimization.aspx>. [Accessed 3 March 2017]

41. Ministry of Infrastructure, *Ontario Community Infrastructure Fund – Formula-based Component*, Program Guidelines (Toronto: MOI, 2016).

42. Stakeholder meeting, November 2016. For example, sub-metering incentives are available through the Save on Energy Retrofit program, and data monitoring incentives are available through the Save on Energy Monitoring and Targeting Program.

43. "Audit Funding", online: Save on Energy <www.saveonenergy.ca/Business/Program-Overviews/Audit-Funding.aspx>. [Accessed 3 March 2017].

44. "Detailed Analysis of Capital Intensive Modifications", online: Save on Energy <saveonenergy.ca/Business/Program-Overviews/Audit-Funding/Detailed-Analysis-of-Capital-Intensive-Modificatio.aspx>. [Accessed 3 March 2017]

45. Stakeholder meeting, November 2016.

46. *Certification of Drinking Water System Operators and Water Quality Analysts*, O Reg 128/04; Licensing of Sewage Works Operators, O Reg 129/04.

Chapter 4

Can Asset Management Improve Energy Efficiency?

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Why do municipalities spend so little on energy efficiency in water systems?

Will asset management planning help?

Abstract

The provincial government now requires municipalities to have municipal asset management plans in order to access infrastructure funding. Asset management planning is supposed to help municipalities make "the best possible decisions regarding the building, operating, maintaining, renewing, replacing and disposing of infrastructure assets". These plans are intended to direct limited resources towards the most critical needs over the entire life cycle of a municipality's entire infrastructure.

However, asset management planning needs adjustment to produce energy and environmental benefits for municipal water and wastewater systems. For municipal drinking water and wastewater systems, the most important roles of asset management planning are:

- to identify the true long term costs of maintaining water and wastewater infrastructure to acceptable service levels, including life-cycle energy (and potentially greenhouse gas) costs, and
- to trigger discussion as to how to sustainably fund these systems.

In theory, asset management should motivate greater investment in energy efficiency, by bringing these long-term costs into all decisions on infrastructure maintenance, repair and replacement. It should also help provide adequate funding for such investments, by setting out an irrefutable case for higher water rates.

In practice, Ontarians are rarely told the true cost of sustainable water and wastewater systems, and asset management planning does not yet drive better energy efficiency. Asset management plans are of variable quality and often based on inadequate data. Although water and wastewater systems are usually a municipality's largest energy uses, energy use is still typically left out of the asset management evaluation. Finding the funding for large efficiency projects remains difficult, even for projects that would quickly pay their way in energy savings.

The province should help municipalities to use asset management planning to trigger cost-effective energy efficiency investments for municipal water systems. If carefully designed, the proposed asset management regulation could help prioritize projects.

4.1. Introduction

As introduced in chapter 2, water and wastewater treatment facilities are usually the single largest energy uses for a municipality. Energy use in many municipal water and wastewater systems is higher than it needs be, and there are many opportunities for energy savings. To date, there is little sign that these opportunities are being acted on, particularly if capital investment is required.

The reasons why improving energy efficiency have not been a priority in municipal water and wastewater systems are complex. Municipal finances, council priorities, and technical capacity all play a role. Municipal governments own about 60% of Ontario's infrastructure, more than any other order of government.[1] On a replacement value basis, about 30% of municipal assets are water and wastewater infrastructure, representing about 18% of Ontario's infrastructure.

Yet many municipalities have aging water and wastewater systems coupled with limited financial and human resources, competing municipal priorities and significant budget shortfalls.[2] This combination has led to systematic underinvestment in energy efficiency and greenhouse gas reductions in their water and wastewater systems.

Long-term underinvestment in water and wastewater assets has produced a critical shortfall. A survey of 120 Canadian municipalities, including 36 from Ontario, found that re-investment rates in all classes of water and wastewater infrastructure were lower than target rates (Table 4.1). The Canada-wide estimate to replace water and wastewater assets which are assessed to be in "poor or very poor" condition is $51 billion.[3] In November 2016, the Ontario Sewer and Watermain Construction Association, made a submission to the Ministry of Infrastructure (MOI), which also made the point that wastewater infrastructure in Ontario was very much underfunded.[4]

Long-term underinvestment in water and wastewater assets has produced a critical shortfall.

Table 4.1. Target and Actual Investment Rates in Water and Wastewater Infrastructure (Excluding Stormwater Systems)[5]

Asset Category	**Target Investment Rate**	**Current Investment Rate**
Water assets – linear	1.0%-1.5%	**0.9%**
Water assets – non-linear	1.7%-2.5%	**1.1%**
Wastewater assets - linear	1.0%-1.3%	**0.7%**
Wastewater assets – non-linear	1.7%-2.5%	**1.4%**

Note: Investment rates are reported as percentage of asset replacement value. Linear assets are the pipes and non-linear assets are "bricks and mortar" facilities like treatment plants and pumping stations.

Source: Federation of *Canadian Municipalities. Canadian Infrastructure Report Card: Informing the Future* (2016), 11

In this context, capital investments for projects that do not address immediate health, safety, or performance concerns often stand little chance of being funded. Energy efficiency is often not considered, or is seen as a frill. This may be the case even though projects that may quickly pay their way in energy savings.

How should a municipality decide when and where to invest in its water and wastewater infrastructure? What influence should energy efficiency and greenhouse gas reductions have in these decisions?

The timing is critical, as large investments in water and wastewater infrastructure are in the process of being made through federal-provincial infrastructure funding. If energy reduction is not a priority in these investments, the opportunity to improve efficiency in these systems may be lost for a generation or more.

Asset management planning (AMP) is supposed to help. In theory at least, it can improve municipal focus on energy efficiency in the long-term management of the water and wastewater assets. Asset management planning formalizes processes to acquire, use and look after physical assets over their whole life cycle, on the basis of appropriate data and service goals. It is intended to help asset owners make "the best possible decisions regarding the building, operating, maintaining, renewing, replacing and disposing of infrastructure assets".[6] It allows municipalities to prioritize investments between different types of assets; e.g., between street lighting and bridges, so that each municipality can develop a long-term capital investment plan for all its major assets.

The Province views municipal asset management plans as a pre-requisite for productive discussions about solutions to municipal infrastructure challenges. These plans are supposed to ensure that limited resources are directed towards the most critical needs over the entire life cycle of a municipality's entire infrastructure. In the U.S., asset management based decisions are expected to help save wastewater utilities 20% - 30% of future lifecycle costs.[7] Figure 4.1 gives a graphical representation of how continued investment pays off over the long term for assets.

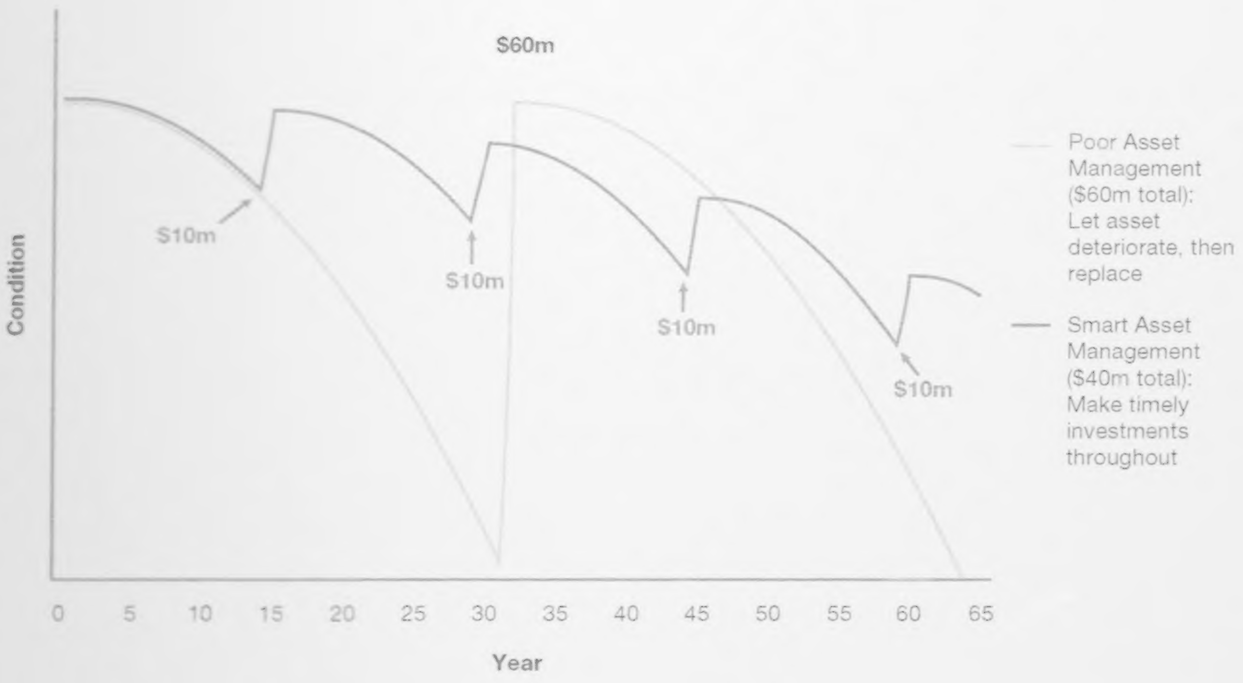


Figure 4.1. Investing in maintenance of assets pays off over the long term

Source: Ontario Ministry of Infrastructure, *Building Together - Guide for Municipal Asset Management Plans* (2012), 10

4.2. Underinvesting in Energy Efficiency and Clean Energy

The starting point is that other initiatives have been only modestly successful in encouraging energy efficiency in the water/wastewater sector.

Utility Energy Conservation

Utility ratepayers fund system-wide conservation programs, e.g., the electricity conservation program managed by the Independent Electricity System Operator (IESO). These programs have had little impact on the water sector. As discussed in Chapter 3 (reporting), the IESO provides partial funding for energy audits and for energy managers to identify energy-saving opportunities in municipal water systems. However, most of the energy efficiency projects that were identified in such audits, even those that will pay back quickly through energy savings, have not been implemented.[8]

Energy conservation projects in water systems funded by IESO between 2011 and 2015 combined are estimated to save about 6.3 gigawatt-hours (GWh) of electricity per year (enough to power about 700 homes).[9] This represents about 0.15% of the electricity savings achieved among all Ontario electricity customers.[10] Yet, municipal water systems consume about 1.3% of Ontario's electricity use.[11] In other words, the water sector has only realized one-tenth of the proportional electricity savings from conservation programs that the average Ontario customer has.

The starting point is that other initiatives have been only modestly successful in encouraging energy efficiency in the water/wastewater sector.

The water sector has only realized one-tenth of the proportional electricity savings from conservation programs that the average Ontario customer has.

To improve participation of municipal water and wastewater facilities in electricity conservation programs, the IESO funded a pilot project undertaken by the Ontario Clean Water Agency (OCWA).[12] OCWA provided free energy "walk-throughs" of facilities to identify potential energy savings, and follow-up assistance to move projects towards implementation. While this popular program reached 98 municipalities, a year later less than 20% of the identified energy savings were being captured, although some additional projects will likely be completed in subsequent years.[13] The pilot program ended in December 2014. OCWA now has a pay-for-performance agreement with the IESO to deliver additional energy savings in the water and wastewater sector.

The ECO's water-energy efficiency survey (Appendix A) found that slightly more than half of responding municipalities have participated to some degree in energy conservation programs (in some cases, audits only; in other cases, implementation of capital projects). The IESO saveONenergy programs and OCWA energy audits were mentioned most frequently. Most municipalities who participated in these programs rated their experience positively. Variable-frequency drives for pumps, lighting retrofits, and aeration blowers for wastewater treatment were some of the energy-saving technologies implemented.

Federal and Provincial Grants

The federal and provincial governments provide capital funding for water and wastewater infrastructure, but do not focus this funding on energy efficiency. For the Ontario Community Infrastructure Fund, none of the funded water or wastewater projects were primarily driven by energy savings,[14] and the competitive component of this fund prioritized projects that addressed health or safety needs.[15] The ECO cannot confirm whether energy efficiency was also considered in projects that were undertaken to achieve other project objectives (e.g., water main replacements, or pumping station upgrades). For phase one of the Clean Water and Wastewater Fund, energy was again not a primary driver, but MOI did provide two examples of projects submitted by municipalities that would have energy efficiency benefits (ultraviolet units and chemical energy-efficient upgrades by the Township of Perth, and variable frequency drives for water pumps by the municipality of Mattice-Val Côté).[16]

There are a few energy initiatives reported in the federal gas tax projects for wastewater; one example is Oakville's new anaerobic digester.[17] However, projects with an energy efficiency component are a very small minority.

Municipal Energy Conservation Plans

Ontario's energy reporting regulation, O. Reg. 397/11 (discussed in Chapter 3), also requires municipalities to develop five-year energy conservation plans for municipal facilities. The first five-year plans were published in 2014, and their depth of analysis varied widely. Most plans did not include formal conservation targets, and gave little attention to water and wastewater facilities, certainly not in proportion to their high share of overall municipal energy use.

4.3. Asset Management for Ontario Municipalities

Guidance from the Ontario Ministry of Infrastructure

The Ontario government requires municipalities to do some asset management planning as part of infrastructure funding programs, but not to assess energy consumption as part of the process.

The Ministry of Infrastructure laid out its vision for asset management in *Building Together: A Guide for Municipal Asset Management Plans*.[18] This document sets out the components MOI expects to see, at a minimum, in an Asset Management Plan, the most important of which are summarized in Table 4.2[19]: Note that each municipality determines its own target level of service for each type of asset.

Table 4.2. Major Components of Asset Management Plans for Ontario Municipalities - an Example

Component of Plan	Description	Water Infrastructure Examples (Niagara Region)[20]
State of local infrastructure	Summarizes key infrastructure assets, estimated value (financial and replacement cost), asset age distribution, expected useful life, and condition (usually based on engineering studies).	455 km of water and sewer mains, replacement value $1.235 billion, approximately 60% of mains built in 1970s or earlier, 99% in "good" or "excellent" condition.
Expected levels of service	Performance measures, targets (and timelines) setting out level of service expected for asset (e.g., water leakage rate of 5%); comparison of current performance to target.	Target level of service is "reliable and economical services 24 hours a day with no interruptions, while complying with existing and future Provincial and Federal legislations." Key performance indicators include number of pipe breaks; operating cost per litre of water; energy use per litre of water.
Asset management strategy	Action plan to "provide the desired levels of service in a sustainable way, while managing risk, at the lowest lifecycle cost."[21] Can include actions related to non-infrastructure solutions, maintenance, renewal/rehabilitation, replacement, disposal, and expansion. Also discusses procurement approaches and risk. Should be based on options analysis and risk analysis.	Condition assessments of infrastructure used to determine urgency of project and potential risks, to feed into budget process. Capital "filters" to help rank and prioritize projects – highest weight given to projects that address compliance, risk, or sustainability.
Financing strategy	Yearly expenditure forecasts to achieve goals of plan, actual expenditures in recent years, revenue sources, identification of any funding shortfall.	Fully funded (as AMP strategy only includes the actions that are included in capital budget). $1.32 billion in capital spending on water/wastewater over 10 years, financed by capital reserve (through rates) (78%), development charges (12%), debt (5%) and funds from higher levels of government (5%).

The province's Municipal Infrastructure Strategy requires a municipality seeking provincial capital funding to prepare an asset management plan and to show how the proposed project fits within the AMP. MOI also committed funding to help smaller municipalities with asset management planning. Tellingly, the *Guide for Municipal Asset Management Plans* gives only one brief mention to energy efficiency and conservation benefits, although it does discuss life-cycle costing options analysis and environmental impacts such as greenhouse gas emissions.

MOI has made asset management planning a requirement for infrastructure grant funding, through both the formula top-up components of the Ontario Community Infrastructure Fund for smaller communities, and phase one of the federal-provincial Clean Water and Wastewater Fund.[22] The Clean Water and Wastewater Fund allocated $570 million in federal funding to Ontario. Ontario will add additional funding, matching recipient contributions up to a maximum of 25% of total eligible costs. The only Ontario-specific requirement for the funding is that a project must be included in a municipality's asset management plan.[23]

Water and wastewater assets form only part of a municipality's asset management plan. They are sometimes given little attention, relative to more visible assets such as roads and bridges.[24] Water and wastewater would have received more focussed attention if the Ministry of the Environment and Climate Change (MOECC) had used the *Water Opportunities Act, 2010*. This Act enables MOECC to develop a regulation that would require municipalities to prepare and submit a Municipal Water Sustainability Plan (including a financial plan and asset management plan) specific to drinking water, wastewater, and stormwater assets. However, no regulation has been passed to implement this requirement, and the MOECC has no plans to do so.[25] Instead, MOI's forthcoming Asset Management regulation (described below in section 4.6) is intended to cover all municipal assets.

4.4. Could Asset Management Improve the Energy Efficiency of Water Systems?

As noted above, energy use and efficiency is not a primary goal of asset management planning. However, there are features of asset management that, if implemented to their full extent, could lead to greater focus on energy efficiency.

In principle, asset management could motivate greater investment in energy efficiency, if asset management plans:

- Recognize water and wastewater as valuable municipal assets;
- Document the true long-term capital and operating cost of maintaining water and wastewater infrastructure to acceptable service levels;
    - These factors should lead to higher water rates, which may reduce non-essential water use and also provide funding for maintenance, such as pipe replacement to reduce leaks.
- Recognize life-cycle energy (and potentially carbon) costs in all decisions on infrastructure maintenance, repair and replacement.
    - For example, life-cycle evaluations of pump performance as part of an asset management evaluation should document the additional energy being used by inefficient pumps, contributing to the economic case for its replacement.

These factors should lead to less emphasis on minimizing initial capital cost and to more emphasis on minimizing life-cycle costs, including improving energy efficiency.

> In principle, asset management could motivate greater investment in energy efficiency.

Water and Full Cost Pricing

One of the most important roles of asset management planning is to identify the true costs of municipal drinking water and wastewater systems to sustain the desired level of service, and to trigger discussion as to how to fund these systems (through rates, grants, development charges, etc.).

Sustainable funding of water assets remains challenging.[26] In part, this may be due to an 'out of sight, out of mind' mentality.[27] The 2017 *RBC Canadian Water Attitudes* survey[28] suggests that Canadians remain reluctant to pay the true cost of water even though they pay one of the lowest levels in the world.[29] Among Canadians, Ontarians pay among the lowest rates after Quebec, as shown in Table 4.3 below.

Table 4.3. Average Residential Monthly Water Payments in 2009

Province	Average rate @ 10 m^3/month	Average rate @ 25m^3/month	Average rate @ 35 m^3/month
Ontario	$ 25.31	$ 53.52	$ 72.41
Alberta	$ 31.98	$ 58.42	$ 76.17
British Columbia	$ 27.53	$ 43.09	$ 54.19
Saskatchewan	$ 40.39	$ 66.40	$ 83.69
Manitoba	$ 35.20	$ 81.34	$ 112.34
Quebec	$ 18.23	$ 20.18	$ 22.21

Source: Ontario Sewer & Watermain Construction Association. *Bringing sustainability to Ontario's water systems: A quarter-century of progress with much left to do* (2016), 52

Politicians have been reluctant to raise taxes/water rates to pay the true cost of these assets on a sustainable basis, regardless of the long-term consequences. By making the potential risks and impacts to level of service more obvious, asset management planning may encourage a more responsible approach to asset investment. It will not directly require full cost pricing, as MOI has clarified that requirements related to recovering costs are outside the scope of current provincial policy.[30]

One way or the other, municipal water users will eventually have to pay the full cost of the water that they use. The ECO has urged municipalities to develop sustainable funding for drinking water systems in our 2013/14 Annual Report,[31] and for stormwater systems in the 2016 technical report *Urban Stormwater Fees: How to Pay for What We Need*. The Canadian Water and Wastewater Association has recognised that municipalities need to have, or commit to develop, a full-cost pricing program when seeking federal funding.[32] The *Guide for Municipal Asset Management Plans* also references the need for some municipalities to raise water/wastewater rates to move closer to full cost recovery.

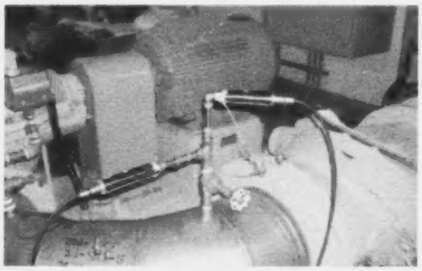
> One way or the other, municipal water users will eventually have to pay the full cost of the water that they use.

Senior government funding is often available to help build large capital projects. For example, the Ontario Community Infrastructure Fund is targeted at small rural and northern communities with an infrastructure backlog. This fund will increase from $100 million per year to $300 million per year by 2018-2019. But, once built, these water and wastewater facilities require sustainable funding so that they will be properly operated and maintained.

Infrastructure maintenance, repair, and replacement – energy implications

Lack of investment over time will naturally result in accelerated wear and tear and asset deterioration and consequently more energy being used. In the long run, this will cost the municipality more than it should for delivering the required service level to its residents.

Deterioration in infrastructure performance over time, causing increased energy use, is most obvious for water pipes. In addition to outright leakage, pipe deterioration and blockages accumulating over time result in higher friction, requiring more energy to pump the same amount of water through the system.[33] But declining energy performance is a concern with all aspects of the water system, not just the pipes. For example, a large scale performance test done in Ontario on 150 water pumps showed that on average, pump efficiency had declined by about 9% since manufacture. Refurbishments of two of these pumps recovered about two-thirds of this drop in efficiency.[34]



Thermodynamic testing to measure pump efficiency.
Source: Hydratek.

Asset management brings a welcome focus on maintaining assets to minimize this drop in performance. It also starts the conversation for every asset as to whether to maintain, repair, or replace. Energy efficiency can and should be part of this conversation. At a minimum, asset management should involve life-cycle cost comparisons that incorporate ongoing energy costs (and the high differential in operating costs between efficient and inefficient equipment). More sophisticated models can incorporate predicted future changes in energy prices (including a value for carbon emissions reductions) and broader consideration of environmental aspects, leading to a more accurate calculation of the sustainability return on investment (ROI). Asset management can therefore help prioritize projects that deliver a higher sustainability ROI.

4.5. Is Asset Management Planning Improving Energy Efficiency in Practice?

Municipal asset management planning is a work in progress, and efforts to date have been inconsistent. Some municipalities will develop a minimal asset management plan in order to receive funding, without much focus on the quality of the plan. AMO's review for federal gas tax funding is a self-reporting model that may check for the existence of an asset management plan, but not for the quality of its contents. Nor has the province taken an active role to ensure the quality or usefulness of the plans. Although MOI has made an asset management program a condition of infrastructure funding, it is not clear whether the Ministry checks how good the plans are; only for the top-up component of the Ontario Community Infrastructure Fund is the quality of an asset management plan a factor in MOI's infrastructure funding decisions.[35] Poor quality asset management plans may not achieve the desired objectives discussed in section 4.4.

> Poor quality asset management plans may not achieve the desired objectives.

Through a review of asset management plans and discussions with municipal staff and other experts, the ECO identified three major concerns:

- Municipal staff capacity to develop AMPs is sometimes lacking, and AMPs are often not based on appropriate field data.
- The link between the AMP and capital budget project selection is weak.
- Energy use, energy efficiency, emissions reductions, and water conservation usually receive little consideration.

Limited Municipal Capacity and Data

In terms of competency and technical understanding, some municipalities have the required expertise and others do not. Some municipalities hired specialized consultants to develop their asset management plans; many others prepared only very basic plans.

Ontario provided funding support to smaller municipalities for the development of asset management plans through the Ontario Community Infrastructure Fund.[36] AMO and the federal government (through the Municipal Asset Management Program delivered by the Federation of Canadian Municipalities) are also helping build knowledge among staff and councillors for municipal asset management planning.[37] This will be a continuous improvement process.[38]

Despite this assistance, the quality of AMPs varies widely. A recent study by the University of Toronto identified concerns with staff capacity and data quality in asset management plans as applied to roads and bridges. The same concerns likely apply to water and wastewater infrastructure.

A good AMP depends on high-quality field data of the conditions of individual assets, including energy audits of key energy-using processes and equipment. In practice, the data foundation for many AMPs is shaky. For example, many municipalities estimate pipe condition based solely on the age of the pipes, not on assessing the actual condition of those pipes. As another example, the frequency of condition assessments may be quite infrequent (e.g., 20 years for treatment plants). Opportunities to correct declining levels of performance between these assessments are likely to be missed. Methods of field data collection are continuously improving as new technology becomes available. It would be helpful for MOI to provide guidance on what data should be collected, and best practices for collecting and interpreting this data.

Weak Link Between Asset Management and Budgeting

The municipal capital budget is where the rubber hits the road in infrastructure planning. A large number of possible projects must be whittled down to those that will actually be funded and built. Each municipality must choose between competing projects - e.g., should it repair a stretch of road, or replace a water pump? Some municipalities separate their water and wastewater budgets from other municipal spending, making decisions somewhat easier, although they still need a framework to choose between projects within the water/wastewater system, and often need to co-ordinate with projects in other areas, such as road rebuilds.

The asset management planning process, including an options analysis, is intended to guide these investment decisions. The asset management plan also includes a financial strategy – however, this does not bind municipal councils and provides no guarantee that the strategy will be followed during the budget process. In most municipalities, it is difficult to determine if and how the asset management plan actually affects capital project decisions. For larger municipalities, there can be challenges integrating processes and budget planning across departments.[39] Because AMPs cut across normal municipal business structures, it involves a change from building a budget from the bottom up based on departmental allowances, to optimizing the decision-making process across the entire organization.

> The municipal capital budget is where the rubber hits the road.

Most commonly, the asset management plans in Ontario simply describe general principles used to select projects. The Ontario Coalition for Sustainable Infrastructure reported that 68% of municipalities use asset management plans as one of their tools to prioritize wastewater and stormwater projects, although more training on asset management is required.

However, the ECO heard from several municipalities that AMPs are looking at the "view from a hundred thousand feet" and do not yet play much role in capital planning.[40] Similarly, the energy conservation plan for Utilities Kingston summarizes how the utility makes decisions on energy efficiency investments in their water and wastewater systems, but there is no indication that this links to the asset management plan.[41]

In the absence of a structured decision-making process, energy efficiency tends to lose out to flashier projects. The City of Barrie is an interesting exception. Barrie recently changed their project ranking matrix in the budgeting process to give greater weight to operating cost savings (such as avoided energy costs). This change has enabled energy projects that had failed the project evaluation process in previous years to pass and proceed to implementation.

Figure 4.2 demonstrates a conceptual process of how the information from an asset management plan should lead to real investments on the ground.

Energy Use and Emissions Reductions Get Little Attention in Asset Management Plans

Energy has not been a focus of asset management plans prepared to date. The ECO found no discussion in AMPs about the assumptions made for future energy and carbon costs or how these assumptions impacted life-cycle costing analysis. Few municipalities included any energy-specific targets or performance indicators in their AMPs. There were a few exceptions – for example, Toronto and Niagara include energy intensity (energy per unit of water pumped or treated) as performance metrics (Figure 4.3).[42]

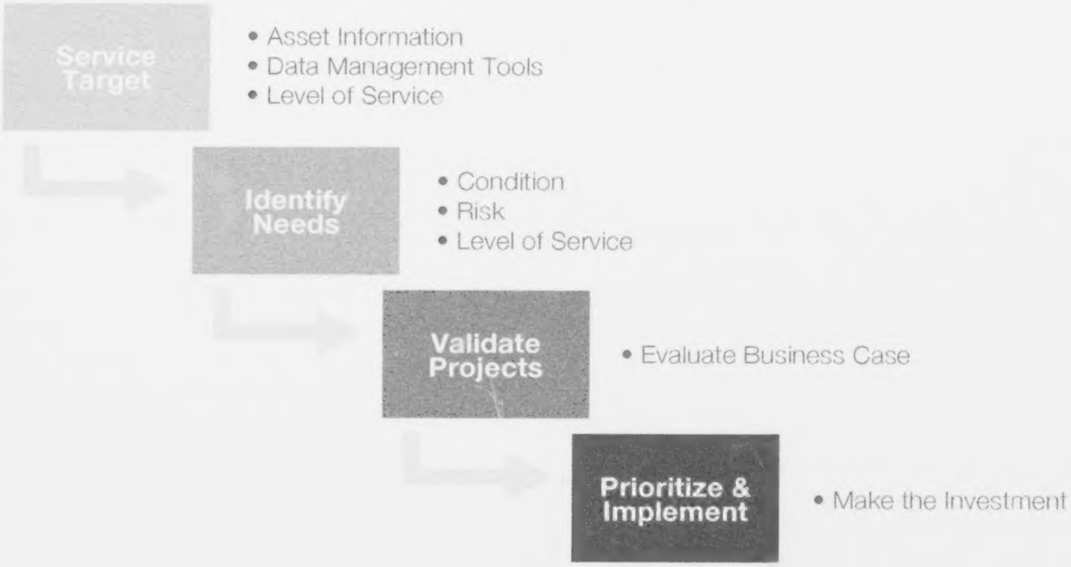


Figure 4.2. How to transform asset management information into implementable projects

Source: City of London. *London Corporate Asset Management Plan 2014*, 1-4

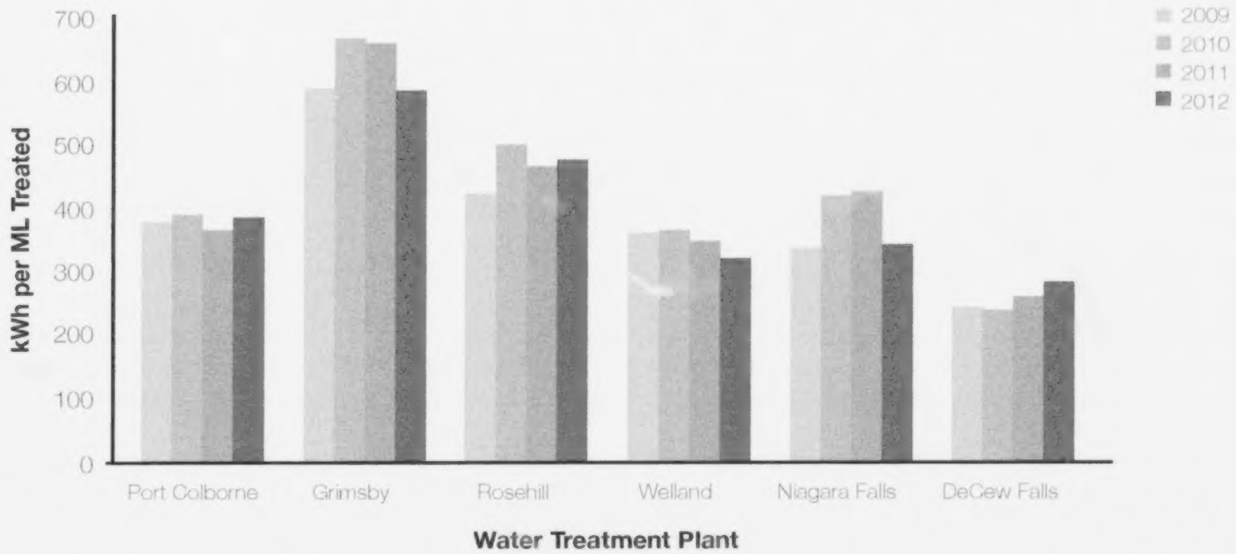


Figure 4.3. Benchmarking energy intensity of Niagara Region water treatment plants

Source: Niagara Region, *Asset Management Plan 2014*, Figure 3.2, 26

The energy impacts of specific projects are not mentioned in AMPs. OCWA indicated that it does include an assessment of the energy implications of projects in their plans.[43] In part, this is due to the high-level nature of AMPs and the lack of detailed field data, mentioned above. References to other internal plans/strategies/reports are sometimes made and it is upon these more detailed reports that the decisions may be made and where energy issues are normally addressed.

However, in the ECO's water-energy efficiency survey (Appendix A), about half (53%) of respondents noted that energy efficiency projects in water and wastewater were considered in their asset management plans – again, likely only indirectly through other plans referenced in the AMP.

The reasons municipalities gave for not including these projects varied considerably. In general, the themes were:

a) Asset management is too new to incorporate findings into the municipal budgeting process;
b) Energy efficiency has not been a focus of asset management planning;
c) AMP focuses on other types of assets;
d) AMP is a high level document and does not go into this level of detail; and
e) Energy efficiency projects are done 'ad hoc' when money is available.

4.5.1 The Lake Huron Primary Water Supply System – Integrating Energy Use Into Asset Management

The best energy conscious AMP that the ECO has seen is the Lake Huron and Elgin Area Primary Water Supply Systems' Asset Management Plan.[44] Energy efficiency and greenhouse gas emissions are part of the AMP "level of service" metrics supporting their sustainability customer service values. To provide data for these metrics, the organization undertook an energy audit and pump optimization study. The energy audit and pump study form a baseline and significant input to the 30-year growth capital plan and asset management plan, including energy targets for 2016 – 2045. The work necessary to reach these targets is considered for investment through the yearly budget cycle which in turn supports project prioritization linked to the level of service framework and risk mitigation strategy.

4.6 Proposed Asset Management Regulation

Both the Ontario and the federal governments have succeeded in getting municipalities to start using asset management as a planning tool. More than 95% of Ontario municipalities had some form of asset management plan in place by 2016, up from less than 40% in 2012. Yet the form and comprehensiveness of these plans varies greatly.[45]

In 2016, the Ministry of Infrastructure began consultation on a proposed regulation for mandatory asset management plans, under the new enabling authority in the *Infrastructure for Jobs and Prosperity Act, 2015*.[46] MOI posted a policy proposal notice and an accompanying discussion paper on the Environmental Registry (Registry #012-8153).[47] The proposal attempts to address some of the issues described in the previous section.

The proposed form of the mandatory asset management plan, as described in the discussion paper, was similar to that described in the *Guide for Municipal Asset Management Plans*, with a few key differences:

- A strategic asset management policy would be required, that would describe how asset management plans link to other municipal plans, particularly financial plans and budgets.
- A common set of service level indicators for major assets, e.g., number of water main breaks per year (the regulation would not prescribe the numerical targets for these levels of service) would be specified by MOI, which all municipalities would need to report on.
    - Energy use and efficiency will likely not be a service level indicator, as the indicators are focused on a specific service that end users receive.[48]
- An options analysis underpinning the infrastructure activities selected by municipalities would be required, that would explain why these activities were the best options. Life-cycle costing and risk analysis would be required elements.

The Registry proposal also noted the need for good infrastructure planning to incorporate sustainability and address environmental concerns, including (but not limited to) water quality, and climate change mitigation and adaptation. It is unclear whether the regulation will apply to alternative ownership structures, such as joint municipal water boards where water/wastewater assets may not be reported on a municipality's financial statements.

A more detailed regulatory proposal that builds on the policy proposal and specifies the content of the proposed regulation is expected to be posted on the Environmental Registry in spring 2017. The ECO was provided with an advance draft of the regulatory proposal, and provided comments to MOI. At the time this report went to press, the proposal had not been publicly posted, and it was not known whether and how MOI would incorporate the ECO's comments into the regulatory proposal or the final regulation.

ECO Recommendations

Asset management planning for municipalities in Ontario is quite new, and should improve over time. If used correctly, and integrated within the management activities of municipalities, asset management planning can be a valuable tool to help choose between competing investment decisions.

MOI's proposed asset management regulation is a step in the right direction that addresses some key concerns. In particular, the ECO views options analysis (particularly the emphasis on life-cycle costing) and the tighter link between asset management and capital planning as welcome and necessary enhancements.

However, to date, asset management planning in Ontario has had little impact in raising the priority given to energy efficiency or water conservation when municipalities make water system investments. The ECO is not convinced that the asset management regulation, as proposed, will do enough to change this and provides some additional suggestions.

Require Consideration of Energy Costs in Life-Cycle Analysis: While life-cycle costing *should* include operating energy costs, including the cost of carbon, MOI should make this an explicit requirement. To facilitate this analysis, it would be valuable for MOI to provide estimates for future energy and carbon costs that can be used by all municipalities.

Encourage Performance Measures for Energy Efficiency: MOI proposes that energy will not be a "service-level indicator" that municipalities will be required to report on and set goals for, as (in MOI's view) it is not a service that the end user receives. While energy use and carbon emissions may not be a service per se, they are certainly an indicator of how efficiently and sustainably a municipality is providing water and wastewater services to its residents. MOI should strongly encourage municipalities to report on energy efficiency metrics in their asset management plans, and should provide guidelines for numerical targets. These metrics may be for energy or emissions intensity (energy or emissions per litre of water pumped or treated) and/or for efficiency of water use, such as leakage rate or water use per resident. Ideally, these targets will be identical to those developed as part of a municipality's conservation plan for O. Reg. 397/11 – including them within the asset management plan serves as a reminder that they should be considered during infrastructure planning.

Collect, Host, and Allow Comparisons of Field Data: Field data supporting asset management plans should be publicly available to allow external analysis to be done effectively. The ECO suggests that MOI collect and host a repository for the field data collected through AMPs, to allow municipalities to compare the performance and condition of their assets (and the techniques used to determine this) to their peers. The Ministry could also use this information to provide best-practice guidelines for key energy-related performance indicators, such as leak rates or pumping efficiency, while still recognizing that each municipality will have unique factors that affect its energy use.

Consider Water Conservation and Non-Infrastructure Alternatives: As noted earlier, it appears that municipal asset management will be regulated under the *Infrastructure for Jobs and Prosperity Act, 2015* and not under the water/wastewater-specific authority in the *Water Opportunities Act, 2010* (Part III). This regulatory authority included the ability to require a water conservation plan and/or performance targets and indicators. As discussed in Chapter 5, water conservation has great potential in many communities to defer or eliminate the need for infrastructure upgrades and can also save energy costs.

While the *Guide for Municipal Asset Management Plans* notes the ability to include "non-infrastructure solutions" such as water conservation within the asset management strategy, few municipalities discuss non-infrastructure alternatives to water system infrastructure in their asset management plans.[49] For the asset management regulation, MOI has proposed that the asset management strategy include an analysis of the options considered.[50] This analysis should be required to include non-infrastructure alternatives, such as water conservation where appropriate, as well as an evaluation of greater use of green infrastructure options. The lack of assessments of municipal green infrastructure assets as part of the asset management planning process has been noted previously by the ECO in our Stormwater Report.[51] Such assets include green roofs, wetlands, cisterns and permeable pavements; all of which may have an impact on water quality and quantity entering the wastewater treatment plant. A roundtable discussion in June 2016 hosted by the Southern Ontario Water Consortium highlighted the great opportunity for non-infrastructure alternatives.[52]

Recommendation: As part of municipal asset management planning for water and wastewater infrastructure, the Ministry of Infrastructure should require consideration of:

- ***Energy and carbon costs in life-cycle cost analysis;***
- ***Green infrastructure and non-infrastructure alternatives such as water conservation.***

Make Infrastructure Funding Contingent on Consideration of Energy Efficiency Opportunities: While the suggestions above should improve municipal consideration of energy within asset management, this will take time. Decisions will be made very soon on hundreds of millions of dollars in water and wastewater infrastructure spending, and it cannot be taken for granted that the asset management process alone will be sufficient to ensure adequate consideration of energy and climate issues.

Ontario will soon negotiate an agreement with the federal government specifying how the infrastructure dollars in the second phase of federal infrastructure funding will be spent. As noted, the only Ontario-specific criterion used in phase one was inclusion of the project in a municipality's asset management plan. Phase two of the federal funding is focused on green infrastructure, including projects that reduce greenhouse gas emissions.[53] Ontario should ensure that the projects it supports for phase two funding have considered energy and emissions impacts, and how to reduce them. This should include both projects where a core goal is energy efficiency or emissions reductions (e.g. pump replacement, anaerobic digestion with energy recovery) and projects for other purposes (e.g. plant expansions) where opportunities for energy-efficient design exist.

Recommendation: In water and wastewater infrastructure projects supported by provincial funding, the Ontario government should require consideration of opportunities to reduce energy use and greenhouse gas emissions.

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Chapter 5

Water Conservation

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We spend a lot of money, energy and GHGs treating water.

Why waste so much of it?

Abstract

Because of the huge energy footprint of treated potable water, and the high cost of water/wastewater infrastructure, municipalities save both money and energy when its water customers and its own facilities use water more efficiently. Water conservation (including water reuse) can also minimize the harmful effects of excess water-taking on aquatic ecosystems, while keeping water available for other water uses, including population growth and agriculture. While per capita water use in Ontario has dropped in the past twenty years, it is still wastefully high.

The provincial government should:

1. set higher efficiency standards for water fixtures in new buildings and at point-of-sale;
2. ensure that individual water metering can be installed in multi-unit buildings;
3. facilitate greywater and rainwater reuse;
4. require municipalities to consider conservation, especially of outdoor water use, as an alternative to new water infrastructure;
5. require water reporting for the broader public sector; and
6. look for opportunities to integrate water and energy conservation programs.

5.1 Why is Water Conservation Important?

Water conservation is essentially energy conservation in another form. Every litre of water that does not need to be treated, pumped, and collected and treated in the wastewater system, reduces energy use, roughly in proportion to the percentage drop in water use.[1] Water conservation can also avoid expensive water/wastewater plant expansions or upgrades, and deliver environmental benefits by reducing the impact of water-takings on aquatic and wetland ecosystems (see text box 5.1.1).

> Water conservation is essentially energy conservation in another form.

For these reasons, water conservation should be a key part of the water infrastructure planning of all municipalities, particularly those with an increasing population. Implementing water conservation requires stepping outside the boundaries of the municipal water system to reach end users in the community, and thus requires a different set of policy tools.

In this chapter, we look at:

- Trends in water use in Ontario municipal water systems;
- The roles of the province and municipalities in delivering water conservation;
- How water pricing and metering can reduce water waste;
- Opportunities for codes and standards to reduce indoor water use in buildings; and
- How and why to reduce the summer peak in water consumption by addressing outdoor water use.

We conclude with recommendations on initiatives the province can take to facilitate water conservation in Ontario.

5.1.1 The Environmental Benefits of Water Conservation

By reducing the amount of water extracted from the natural environment, water conservation can deliver significant environmental benefits, in addition to reducing energy and infrastructure costs.

Municipal water systems obtain their water either from surface waterbodies or watercourses (roughly 90%) or from groundwater, through wells (roughly 10%).[2] Although most of the water is returned to surface waters after wastewater treatment, the quality and temperature of the water is usually altered. In addition, the water is usually returned to the environment in a different location, sometimes in a different watershed. All three types of changes - quantity, quality and location - affect the local water cycle.

The environmental impact of municipal water-takings is particularly important for those communities that do not draw their water from the Great Lakes, simply because water-takings have more impact on groundwater, smaller waterbodies, and streams. In these areas, water taking and wastewater discharge can cause conflict with other water users (e.g., lowering the water level in wells) as well as:

- Reduced local water quality;
- Lower water levels in lakes (impacting aquatic and shoreline habitats);
- Water flow reductions in streams (in extreme cases, changing permanent streams to intermittent streams), affecting aquatic biota;[3]
- Loss of wetlands and springs; and
- Increases in summer stream temperatures, eliminating cold or cool water habitat that many fish species require.

Like most other major water users, municipal drinking water systems require permits to take water under the *Ontario Water Resources Act*, specifying the maximum volume of water that can be withdrawn. When reviewing applications for new permits (or for increases to permitted volume of water withdrawn), the Ministry of the Environment and Climate Change (MOECC) is required to consider the potential impact on natural ecosystem functions. In practice, this system has many gaps, and does not adequately monitor and protect ecosystem functions.[4]

In areas where water taking could negatively impact natural ecosystems, municipalities may have difficulty obtaining permits for new or increased water-takings. As part of source water protection planning under the *Clean Water Act, 2006*, source protection committees developed water budgets between 2006 and 2010 for many watersheds to assess whether water quantity threats, including municipal water takings, could compromise municipal water supplies. Significant water quantity threats were identified in parts of 7 of the 22 Source Protection Areas and Regions covered by source protection plans. This includes areas slated for significant population growth. Some such areas, such as Guelph and Orangeville, have made water conservation a high priority.

Low Summer Flows and Climate Change

Water-takings have their greatest impact on ecosystems during drought conditions, often in late summer, when water levels and stream flows are at their lowest. This is usually when municipalities take the most water, and when competing water demands, e.g., for agriculture, also peak.

Water conservation can help reduce the environmental damage caused by water taking.

In 2016, much of southern Ontario experienced serious drought, with eastern Ontario reaching Level III (the most severe level of water stress) under the Ontario Low Water Response program (Figure 5.1). This meant that water supply was officially inadequate to meet demand, and resulted in conservation authorities requesting users to reduce their water use.[5]

Climate change will likely increase the frequency and severity of droughts. Together, lower snowpacks, longer, hotter and drier summers, and more of the rain being concentrated in extreme events, are expected to reduce summer baseflow to rivers and streams.[6] While not a panacea, water conservation can help reduce the environmental damage caused by water taking, especially during droughts.

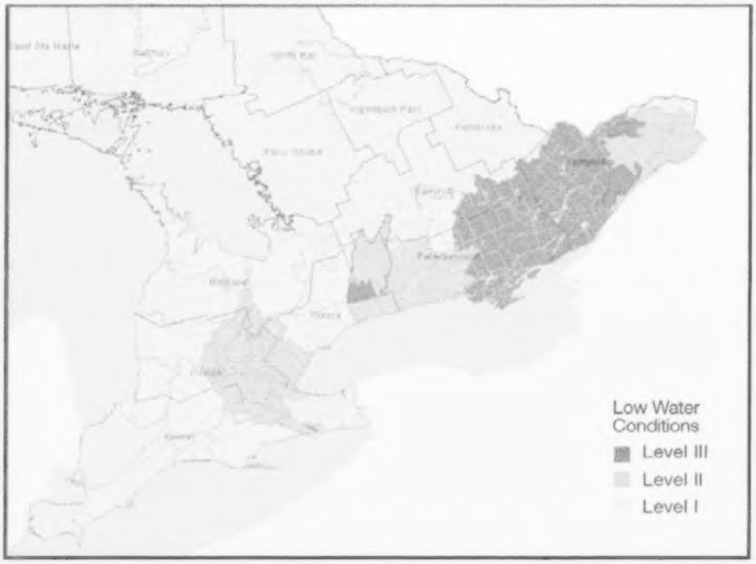

Figure 5.1. Low water conditions, southern Ontario, August 31, 2016

Source: Ontario Ministry of Natural Resources and Forestry

5.2 How Much Water do we Use?

According to the Organization for Economic Development and Co-operation, Canadians use the fourth most water per capita of 28 nations profiled, withdrawing approximately 1000 m^3 of water per person per year.[7] Ontarians use even more water, roughly 1745 m^3 per capita in 2011.[8] These statistics include water takings for all uses except hydroelectric power production, and are heavily dependent on a jurisdiction's energy, agricultural, and industrial mix. As shown in Chapter 1, 86% of Ontario's overall water takings are used for thermal power production, primarily cooling water used at nuclear power plants on Lake Ontario.

In terms of municipal water systems, the most recent comprehensive Ontario data is from Statistics Canada's *Survey of Drinking Water Plants, 2013*. In 2013, Ontarians took, on average, 386 litres of water per person per day from municipal systems, including 200 litres per person per day for residential use. This is slightly less than the Canadian averages of 466 litres per person per day for all municipal use, and 223 litres per person per day for residential use.[9] We found no comprehensive international benchmarks, but a 2008 United Kingdom study showed that many European nations use only 110-150 litres per person per day for residential use.[10] This illustrates the great potential for water conservation in Ontario. Some municipalities have targets close to these levels of efficiency; Guelph's residential water use was 180 litres per person per day in 2013, and the target is to reach 157 litres per person per day by 2038.[11]

Water use from Ontario municipal systems has been declining, both as an absolute quantity and on a per capita basis. Though Ontario municipal drinking water systems served one million more residents in 2013 than in 2005 (11.6 million vs. 10.6 million), total potable water consumption fell 13%, from 1.88 billion m^3 to 1.63 billion m^3.[12] Per capita consumption fell even further between 2004 and 2013, by 20% for total water use and 23% for residential use, as shown in Figure 5.2.

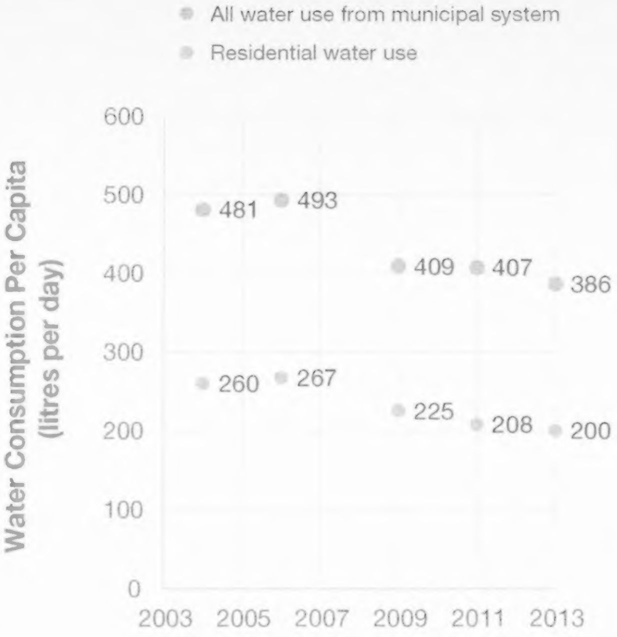

Figure 5.2. Water consumption per capita, Ontario municipal drinking water systems

Source: Statistics Canada, *Municipal Water Use Report* (multiple years);[13] Table 153-0127 from *Survey of Drinking Water Plants, 2013* (2015)[14]

Water use is decreasing across North America, driven primarily by more efficient water fixtures and appliances. The *Residential End Uses of Water Study, 2016* studied water use in 23 water utilities across North America and found that indoor water use in single-family homes had fallen by 15% per person between 1999 and 2016. Ontario-specific factors discussed in this chapter, such as municipal water conservation programs, near-universal water metering, and water efficiency standards in the Ontario Building Code, may account for the sharper decrease in Ontario residential water use.

5.3 Provincial and Municipal Roles in Water Conservation

The province and municipalities both have roles in encouraging water conservation.

5.3.1 Provincial Role

The Ontario government's water conservation tools include its power to:

1. Set codes and standards for appliances and other products;
2. Mandate water reporting;
3. Require municipal water sustainability plans, and
4. Make voluntary water conservation programs, supported by dedicated funding, available to customers across Ontario, as it has done for electricity and natural gas.

So far, it has made limited use of these tools.

Codes and Standards

The province can set requirements for water conservation in new buildings through the Ontario Building Code, and is supported in this role by the Building Code Conservation Advisory Council. It can also establish water efficiency standards for appliances and other products sold in Ontario, under either the *Green Energy Act, 2009* (for products that also use energy, such as clothes washers and dishwashers), or the *Ontario Water Resources Act* (for all other products that use water, such as water fixtures).

The Ministry of Municipal Affairs (MMA) consulted on changes to the Building Code most recently in fall 2016. No significant amendments related to water efficiency were proposed, but a second phase of consultation is forthcoming, with the intent of bringing in changes for the 2019 Building Code. MMA has indicated that some proposals related to water efficiency are likely to be part of this consultation.[15]

Specific opportunities for codes and standards are discussed in Section 5.5.

Water Reporting

As described in Chapter 3, Ontario mandates energy reporting, but not water reporting, by the broader public sector (i.e., municipalities, universities, hospitals, etc.).[16] Ironically, wastewater treatment plants are often large consumers of potable water. In contrast, large private sector buildings will soon be required to report their energy **and water** consumption, via the online tracking and benchmarking tool Portfolio Manager.[17] The goal is to promote water conservation efforts in these buildings.

Knowing how much water a facility consumes, particularly in relation to other similarly-placed buildings, makes it easier to identify opportunities for savings, exactly as it does for energy use. Figure 5.3 provides a clear example of how water use reporting can help building owners compare their water use against other similar buildings and determine if they need to improve efficiency and reduce water use.

Water reporting by the broader public sector facilities (i.e., municipalities, universities, hospitals, etc.), preferably through Portfolio Manager, would enable these customers

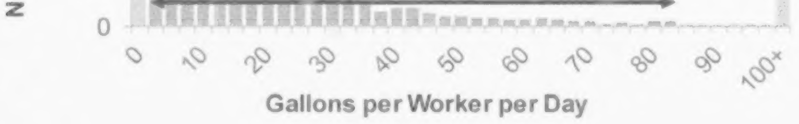

Figure 5.3. An example of water use benchmarking for office buildings

Source: ENERGY STAR Portfolio Manager, Water Use Tracking (Factsheet)

Ontario mandates energy reporting, but not water reporting, by the broader public sector.

to better assess and reduce water use (and bills) in their own buildings. Municipalities would also benefit from water conservation in broader public sector buildings, by reducing the amount of potable water they would need to treat and pump.

Water Sustainability Plans

As discussed in Chapter 4, the *Water Opportunities Act, 2010* enables MOECC to develop a regulation that would require municipal water systems to develop a Municipal Water Sustainability Plan, including a water conservation plan, and strategies for maintaining and improving the municipal service relating to water use and impacts on Ontario's water resources. Such plans would assess the value of water conservation to the particular water system, and determine whether municipal resources and funds should be dedicated to water conservation. This authority has not been used.

The MOECC has required York Region and municipalities within the Lake Simcoe watershed to prepare and implement water conservation and efficiency plans, but under different legal authority (the Environmental Approval for York Region's Southeast Collector Trunk Sewer twinning, and the Lake Simcoe Protection Plan). In these circumstances, strong site-specific drivers for water conservation existed - concerns about minimizing the amount of wastewater from York Region to be treated in Durham Region and discharged into Lake Ontario, and preserving adequate in-stream flows in the Lake Simcoe watershed, respectively.

The Ministry of Energy also provides some funding for local energy planning through its Municipal Energy Plan grant program. Four of the first six plans (for Wawa, Temiskaming Shores, Woodstock, and Vaughan) completed under this program do reference water conservation measures.

5.3.2 Wawa: Integrating Water and Energy Conservation

Wawa is a small municipality in Northern Ontario that has integrated community water conservation initiatives into its energy conservation planning. Wawa's *Municipal Energy Plan* (completed in early 2016 with funding assistance from Ontario's Municipal Energy Plan grant program) notes that per capita water use in Wawa is three times the provincial average, and needs to be reduced, in part because water use is still increasing and straining the capacity of the new water filtration plant.[18] One reason for the high usage is that water use was unmetered until 2014. Another reason is the need for bleeder valves to keep water flowing in the winter to prevent freeze-up.

Wawa's *Energy Conservation Plan* (required under O. Reg. 397/11) builds on the Municipal Energy Plan and spells out near-term measures to reduce water use.[19] The most important is to start billing citizens based on volume of water use, now that metering is in place. Wawa has hired a community energy planner who will also have responsibility for water conservation. Other near-term actions Wawa is taking include developing a bylaw to restrict lawn watering in the summer and introducing a rain barrel program.

Water Conservation Programs

The province could also make new voluntary water conservation programs, supported by dedicated funding, available to customers across Ontario, as it has done for electricity and natural gas. Why are there no provincial water conservation programs? One reason is that, while the MOECC licences all municipal water systems, there is no provincial *economic* regulator for water providers. In the energy sector, the province has used the Ontario Energy Board to require electric and gas utilities to deliver energy conservation programs.

A second reason is that the economic and environmental value of water conservation varies greatly across communities, more so than it does for energy conservation.[20] Only about 10-15% of a municipality's costs of providing water/wastewater operations are directly proportional to the amount of water consumed.[21] These variable costs include energy and chemical inputs. Water conservation immediately reduces these costs. The remaining 85-90% of costs (mostly from the capital cost of infrastructure) are fixed in the short-term, though not in the long-term. Only a few communities quickly reap large savings in avoided infrastructure costs through water conservation; others do not.

The economic and environmental value of water conservation varies greatly across communities.

Water conservation will be most attractive in:

- Growing communities where population is increasing and water or wastewater plants are nearing capacity;
- Regions at risk of exceeding their sustainable level of water withdrawal from the environment; and
- Greenfield developments where opportunities exist to downsize planned infrastructure.

Where municipal water infrastructure is close to capacity, conservation benefits can be great. In the City of Guelph, water efficiency programs delivered between 2006 and 2014 cost about $1.31 for each litre per day of water savings. By comparison, expansion of water and wastewater treatment infrastructure capacity was estimated to cost $4.68 per litre per day, more than three times as much.[22]

In municipalities where conservation does not avoid infrastructure costs, conservation can be politically unattractive. If the fixed costs of operating the water system must be recovered from a declining volume of water use, water **rates** for customers may rise, at least in the near term, although water **bills** (on average) will fall.[23]

5.3.3 Municipal Role

The municipal role in water conservation begins with its own systems. At least 10% of treated water does not reach end users, but is lost from the distribution system, primarily through leaks. The importance of this leakage, and methods for reducing it, are discussed in Chapter 2.

In terms of customers' water use, municipalities' major influence comes from whether, and how, they use water metering and water pricing to encourage conservation. Aside from that, only a minority of municipalities offer water conservation programs to the public. In the ECO's water-energy efficiency survey, only 27% of responding municipalities offered even one water conservation program to customers, with discounts on rain barrels and water-efficient toilets being the most popular initiatives. Only a handful of these municipalities, such as York Region, Guelph and Waterloo, have detailed plans that spell out the savings expected from water conservation and the programs and actions needed to achieve them.

Municipalities' major influence comes from whether, and how, they use water metering and water pricing.

5.3.4 Charging for Water: Meters and Pricing

Ontario municipalities make better use of water pricing now than they did a generation ago, but there is still lots of room for improvement.

Flat Rates to Meters

Twenty-five years ago, almost one-fifth of Ontario municipal water customers paid a flat fee for their water service, where their bill did not vary with the amount of water consumed. Today, at least 98% of municipal water customers have water meters, and pay by how much water they use (volumetric rates).[24]

Unsurprisingly, water use in Ontario was much higher (35% or more) among users on flat rates (Figure 5.4) than among those who paid volumetric rates.[25] Recently, the Town of Moosonee, ON saw a 20% drop in water use after installing meters and moving to volumetric pricing.[26] Thus, the most important step to conserve water – moving from flat pricing to volumetric pricing – has been largely completed in Ontario.

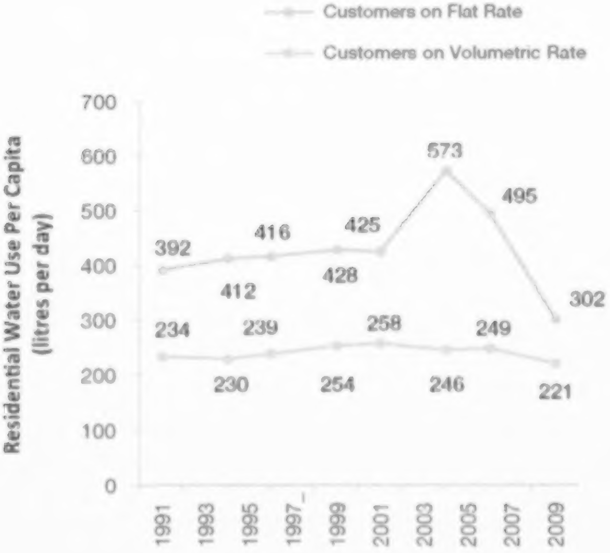

Figure 5.4. Water consumption per capita, Ontario municipal drinking water systems

Source: Ontario Sewer & Watermain Construction Association, *Bringing Sustainability to Ontario's Water Systems*, 2016, p. 38

However, residents in many multi-unit buildings, particularly multi-unit residential buildings (MURBs), still do not pay for their own water use. This is because many MURBs (particularly high-rise buildings) have only one bulk meter connection, offering no ability to bill individual units based on actual consumption. These occupants are, effectively, still on flat rates, and have little incentive to conserve water. This is especially important to address as roughly half of new housing starts in Ontario in recent years have been in multi-unit buildings.[27]

Several municipalities (e.g., Waterloo and Guelph) offer or plan to offer programs to encourage multi-unit buildings to install individual unit water metering where the building plumbing layout permits (individual metering may be impossible or cost-prohibitive in some existing buildings, as it requires a building plumbing layout with a unique point of connection for each unit).[28] In a recent southwestern Ontario project, a 60-unit townhouse complex without sub-metering had per capita water use 26% higher than the municipal average. Once individual units acquired their own meters and paid their own bills, per capita water use fell 20%.[29]

Individual meters are easy to install if the plumbing design plans for them. In low-rise buildings (e.g., row-houses), each unit can usually be connected directly to the municipal system and metered; in a multi-storey building, the more likely option is a bulk connection to the utility system, with individual sub-metering of supply connections from the bulk meter. Hamilton has passed a bylaw requiring individual metering in horizontal MURBs (i.e. row houses) and industrial, commercial, and institutional (ICI) buildings.[30] Hamilton also encourages individual metering in vertical MURBs.

Smart Water Meters

The first generation of meters only measured total water use and had to be read manually, on-site. Today, many Ontario utilities are moving to "smart" water meters that send customer water use data to the utility electronically. This eliminates manual door-to-door meter reading, and can generate much more detailed water use data that can facilitate conservation. For example, metered data at regular intervals (e.g., every hour) makes leak detection easier and faster.

Some municipalities (for example, Toronto's mywaterToronto initiative, see Figure 5.5) offer customers access to their metered data via the Internet, along with instructions on how to use the data to identify leaks.[31] Leaks within the house are estimated to account for 13% of water use in single-family households. The Ministry of Energy is assessing whether to require municipalities to make metered water data (along with electricity and gas data) available to customers in the standardized Green Button data format.[32] This would facilitate multiple options for residential and business customers, and (if desired) third-party conservation services, to analyse water consumption data.

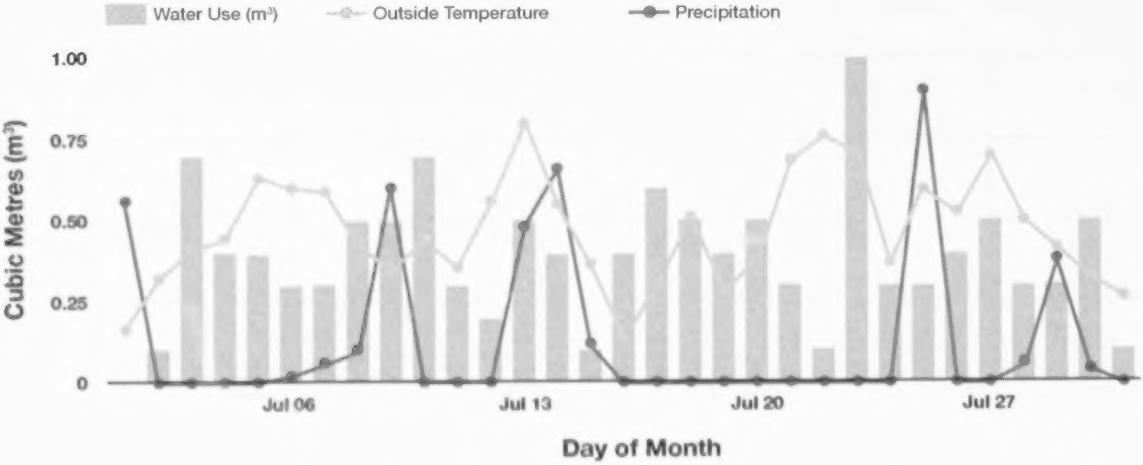

Figure 5.5 Sample customer water meter data from mywaterToronto web portal

Setting Water Rates

The price for water charged by many municipalities is too low to sustainably fund capital, operations and maintenance expenses of their water/wastewater systems, as discussed in Chapter 4. While many Ontario jurisdictions have raised rates significantly in recent years, a large number (at least 41% as of 2013, based on a previous ECO survey) are still not at full-cost recovery. These unreasonably low prices lead to both infrastructure deficits and increased water use. One estimate is that a 1% price increase leads to a 0.16% decline in Canadian residential water use.[33] The ECO has, for years, recommended that the province require full-cost recovery for drinking water systems, as recommended by the Walkerton Inquiry.[34]

Similarly, simple volumetric pricing does not provide appropriate incentives to focus water conservation on the summer peak when it provides the greatest environmental and financial benefits. Better alternatives include higher summer rates, rates that rise with the amount of water use (i.e., increasing block rates), and different rates for indoor and outdoor water consumption. For maximum impact, conservation programs and rate designs should be developed hand in hand.

Water pricing is not covered in detail in this report because it has been reviewed extensively elsewhere. An excellent recent Ontario-specific analysis is *Bringing Sustainability to Ontario's Water Systems*.

> The price for water charged by many municipalities is too low.

5.4 Promising Conservation Targets

We now turn to opportunities to reduce water consumption in specific end uses. The users of municipal water after it has been extracted from the environment and treated are shown in Figure 5.6. The residential sector is the largest consumer of municipal water, accounting for about half of total water use, followed by the ICI sector.

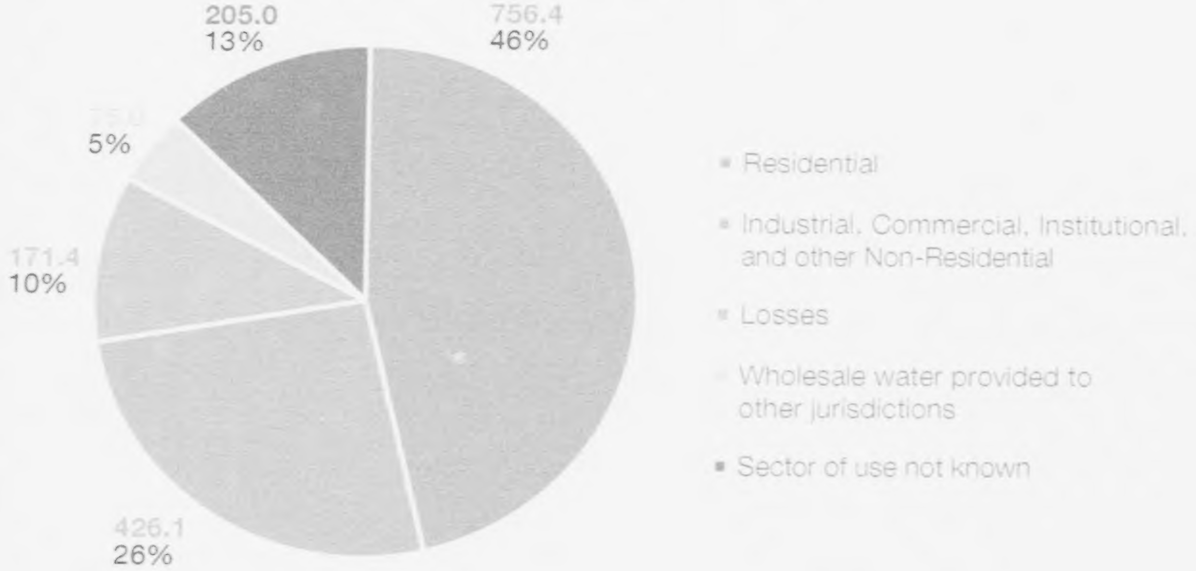

Figure 5.6 Annual water consumption by sector (million m^3), Ontario municipal drinking water systems, 2013

Source: Statistics Canada. Table 153-0127 from *Survey of Drinking Water Plants, 2013* (2015).

Note: Water reported as "losses" is predominantly from leaks, but also includes other non-revenue water use such as maintenance and flushing of the distribution system. "Wholesale water provided to other jurisdictions" would include, for example, the volumes of water collected and treated by Toronto that is provided to York Region.

In both the residential and ICI sectors, water use can typically be divided between:

- Indoor water use from fixtures and appliances (Sections 5.5 and 5.6);
- Outdoor water use, primarily for landscaping (Section 5.7).

Actions to reduce water use in these categories are generally similar for residential or ICI buildings.

In addition, some ICI customers use water in custom water-intensive processes such as food and beverage production. These processes are often specific to the individual business or industry, and are not amenable to one size fits all solutions. Some Ontario municipalities have a "Capacity Buyback Program", which provides a financial incentive for such businesses to reduce their water use.[35] These programs may also provide assistance for an initial water audit to help identify water savings opportunities. Policies to reduce custom ICI use are not discussed further in this report.

5.5 Indoor Use – Efficient Water Fixtures and Appliances

Indoor water use, particularly in residential buildings, is concentrated in a handful of products, as shown in Figure 5.7. This makes it an ideal candidate for codes and standards that set high minimum efficiency levels for these products.

> Indoor water use, particularly in residential buildings, is concentrated in a handful of products.

Toilet	Faucet	Shower	Clothes washer	Leak	Bath	Other*	Dishwasher
24%	20%	20%	16%	13%	3%	3%	2%
123 L/day	**102 L/day**	**102 L/day**	**83 L/day**	**67 L/day**	**17 L/day**	**15 L/day**	**8 L/day**
TIP: Install water-efficient toilet (4.8 litres per flush or lower)	**TIP:** Install water-efficient faucets. Turn tap off while washing dishes, brushing teeth or shaving	**TIP:** Install water-efficient showerheads. Shorten showers. Reduce water temperature for energy savings	**TIP:** Choose water-efficient front-loading washer. Run with full loads. Use cold water setting for energy savings	**TIP:** Check whether water meter is running when no water is being used; test toilets for leaks using coloured dye	**TIP:** Reduce volume of bathwater. Reduce water temperature for energy savings	**TIP:** Use water-consuming appliances (e.g., humidifiers) only when needed	**TIP:** Run with full loads

*The "Other" category includes evaporative cooling, humidification, water softening, and other uncategorized indoor uses.

Figure 5.7: Indoor household water uses

Source: Water Research Foundation, *Residential End Uses of Water, Version 2*, 2016.

Note: Water use statistics based on a sample of approximately 1,000 single-family homes in 23 locations across the United States and Canada. Outdoor water use is not included.

The share of efficient water fixtures and appliances in buildings began to increase in the 1990s, driven primarily by U.S. federal water efficiency standards introduced in 1992. Initially, there was a large efficiency gap between new and existing products (e.g., toilets using 6 litres per flush (lpf), replacing older models that used 13 or even 20 lpf), creating an opportunity for significant water savings. Many municipalities introduced programs at that time to incent customers to upgrade to more efficient equipment in existing homes, primarily clothes washers and toilets. At the same time, gas utilities put significant resources into delivering more efficient showerheads and faucets, to conserve hot water (and natural gas).

Most of these original conservation programs have been cancelled or modified. To deliver further water savings today, water conservation programs or codes and standards must incent or mandate product efficiency levels materially better than the 1992 standards. There are still opportunities for significant water savings, although not as large as the initial round of efficiency improvements (see text box 5.6.1).

For example, the voluntary WaterSense certification is given to products that are more efficient (generally 20% more) than the 1992 standards. WaterSense certification also guarantees that labelled products perform adequately, through third-party performance testing. Almost all showerheads and faucets sold now already meet the WaterSense standard, but only 30% of toilet sales do, at least in the U.S. (data on the Ontario market is not available, but Ontario stores still carry a large number of 6 lpf models).[36] The current WaterSense requirement for toilets is 4.8 lpf.

Under the *Water Opportunities Act, 2010*, Ontario has authority to set point-of-sale standards for toilets and other fixtures sold in Ontario, for example to mandate WaterSense efficiency levels. It has not done so, despite previous ECO recommendations.[37] However, under the *Green Energy Act, 2009*, it has recently passed water efficiency standards for products that also use energy, in particular, clothes washers and dishwashers.[38] For these products, Ontario was able to harmonize with water efficiency standards established by the U.S. Department of Energy. However, for water fixtures that do not use energy, neither the U.S. nor the Canadian government has been active in recent years in setting mandatory efficiency standards. Ontario would need to act alone if it wished to establish such standards.

For new buildings, Ontario has used its authority to improve standards for water fixtures as part of regular Building Code updates. For example, the 2017 Code requires 4.8 lpf toilets in new residential buildings, although not commercial buildings. Water efficiency requirements for toilets have traditionally been weaker in commercial buildings than residential, in part due to concerns about whether low-flow toilets can adequately transport waste through long drainlines. However, recent research by the Plumbing Efficiency Research Coalition has found that transport of waste through drainline systems is not a technical problem for 4.8 lpf toilets in new commercial buildings.[39]

5.6 Greywater Systems – Another Way to Reduce Indoor Water Use

Not all household water use requires water treated to potable standards. Some purposes, such as flushing toilets, could be adequately met with greywater - the relatively clean effluent from bathroom sinks, bath tubs/showers and washing machines.[40] This makes a lot of sense because the average amounts of water used for showering/bathing and toilet flushing are almost equal. This form of water reuse can deliver large water savings, as shown in text box 5.6.1.

Greywater systems are a form of decentralized water reuse, since the system is maintained by the property owner or manager and the collected water is reused within the house or commercial/industrial facility. Greywater systems offer essentially the same benefits as water conservation - cost benefits for the property owner in the form of lower water bills, system benefits as less water is being transported through the water infrastructure, and environmental benefits in the form of lower source water withdrawal and lower energy use and greenhouse gas emissions. Centralized water reuse, typically reusing water collected and treated at a municipal wastewater plant, is discussed in more detail in Chapter 6.

A typical greywater reuse system is similar to Figure 5.8 below. The used water from the showers and sinks flows through a greywater treatment process into a small holding tank that then feeds the reused water to the toilet tanks.[41] More sophisticated systems can include larger water storage tanks, including concrete tanks cast as part of the building foundation, and can also make use of rainwater as well as greywater.[42]

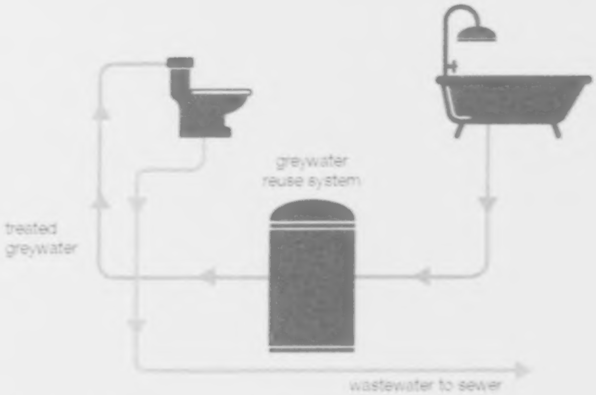

Figure 5.8: Household greywater reuse system

Source: Adapted from City of Guelph. http://guelph.ca/living/environment/water/water-conservation/greywater-reuse-system/

A greywater system in a home requires a dual plumbing system to separate the greywater collected from shower and bathroom sink drains from the city's water lines. A rough-in for a greywater system costs around $500 if it is included during the construction stages of a new home.[43] With the plumbing system in place, a greywater system can be added at any time; until then, potable water continues to be fed to the toilet tanks for flushing.

Greywater tank for domestic water reuse (on left).
Source: Region of Durham

If the plumbing system is not built to be greywater-compatible, the cost to put in a greywater system later can be much more substantial, often thousands of dollars just for the plumbing changes.

Greywater and Rainwater in the Building Code

Amendments to the Ontario Building Code in 2012 clearly define the plumbing standards a greywater or rainwater system must conform to before it is used in homes and businesses, and the allowable uses of greywater and rainwater. Greywater can be used for:

- water closets (toilets);
- urinals;
- sub-surface irrigation; and
- the priming of traps.

Rainwater can be used for these purposes, and also for:

- clothes washers;
- laundry trays;
- mop sinks;
- bedpan washers;
- hose bibbs.

These standards only apply to the plumbing requirements, not the quality or level of treatment required for the reclaimed water. MMA has indicated that the quality of reclaimed water is an area it may include proposals for in the next Code consultation.[44] Some guidance can be found in Health Canada's *Canadian Guidelines for Domestic Reclaimed Water for Use in Toilet and Urinal Flushing*. The first version of the guideline, released in 2010, focused on the end use of toilet and urinal flushing, with the goal of ensuring that the operation of water reuse systems is protective of public health. The intent is for this guideline to eventually become a comprehensive document that will provide recommendations on a variety of water reuse activities.

The document recognizes that reusing water for flushing of toilets and urinals (in commercial properties) reduces water bills and has an overall beneficial impact on the environment. However, because certain microorganisms and pathogens in the reused water can pose a health risk, it proposes guidelines for water quality parameters for domestic reclaimed water used in toilets and urinals.[45] The guideline recommends that at a minimum, all domestic reclaimed water should be disinfected and further chlorinated if required.

5.6.1 Priority Green Clarington Demonstrates Savings In New Homes from Water-Efficient Technologies and Greywater Recovery[46]

Are there still cost-effective opportunities to reduce indoor water use in a typical new house, given that the current Ontario Building Code (OBC) already mandates relatively high water efficiency standards? A recent study in Clarington holds some of the answers. The Priority Green Clarington demonstration project worked with three builders to outfit six new houses with water-saving technologies that go beyond Code requirements:

- Ultra low-flow toilets (3.0-3.8 litres per flush, OBC maximum is 4.8);
- Low-flow showerheads (6.6 litres per minute, OBC maximum is 7.6);
- Low-flow kitchen faucets (5.7 litres per minute, OBC maximum is 8.35); and
- Greywater reuse (in three of the six houses) – using water drained from showers, recovered, and treated, as a (partial) source of water for toilet flushing, replacing potable water.

Water usage at individual water fixtures in the houses was sub-metered over a full year after the homes were sold and occupied, making it possible to determine how much these technologies affected household water use, and what level of water savings could be achieved in comparison to a house built with OBC levels of water efficiency.

The greywater recovery system delivered the largest water savings (13 litres/person/day), providing more than half (59%) of the water needed for toilet flushing. However, it was the only water efficiency measure tested that was not cost-effective, due to its high upfront cost, including installation. These costs may come down as this technology becomes more mainstream.

The other three water-efficient technologies all paid back their upfront costs through savings on the water bill in less than five years. Using the Region of Durham's water and wastewater rates, Priority Green homes without greywater recovery would save $57 on their annual water/wastewater bill, while homes with greywater recovery would save $128 annually.

The project recognized the linkage between water and energy, and estimated the reduction in energy use at the Region of Durham's water/wastewater operations due to the lower volume of water pumped and treated. Water use was responsible for 178 ekWh/year (equivalent kilowatt-hours) of embedded energy use in homes built to Code and 152 ekWh/year in Priority Green homes.

Most notable, perhaps, is the whole-house water savings (Figure 5.9). Homes built to the Priority Green standard used an average of 140 litres per person per day.[47] A billing analysis of 113 similar new homes in the same neighbourhoods built to Code found that these homes averaged 26% higher water use (176 litres per person per day). Even more striking, the average residential per capita water consumption in all existing homes in the Region of Durham was 230 litres per person per day, 64% higher than in Priority Green houses. This strongly suggests that opportunities remain to improve water efficiency in older houses through more efficient water fixtures, management of outdoor water use, and through the installation of greywater systems.

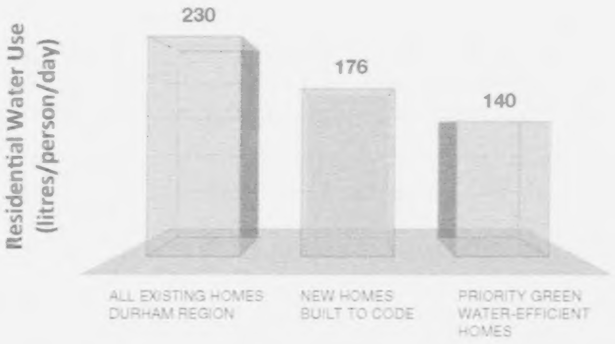

Figure 5.9: Comparison of residential water use intensity in homes in Clarington, ON

Source: Sustainable Edge. *Final Report for Priority Green Clarington - Water and Energy Demonstration Project.*

Notes: Value for "New homes built to Code" is based on metered data for 113 homes. Value for "Priority Green water-efficient homes" is based on metered data for indoor water use for six similar homes, adjusted upwards by 14% to account for outdoor water consumption (which was not metered).

5.7 Reducing Outdoor Water Use

Managing the Summer Peak

Water use in most municipalities is much higher during the summer, largely due to outdoor water use, in particular, lawn watering (Figure 5.10). The size of the summer peak varies from year to year, and is greatest in hot, dry summers (Figure 5.11). System-wide water consumption in summer months is often 30% higher than in other seasons, with an even greater increase among single-family residential customers.

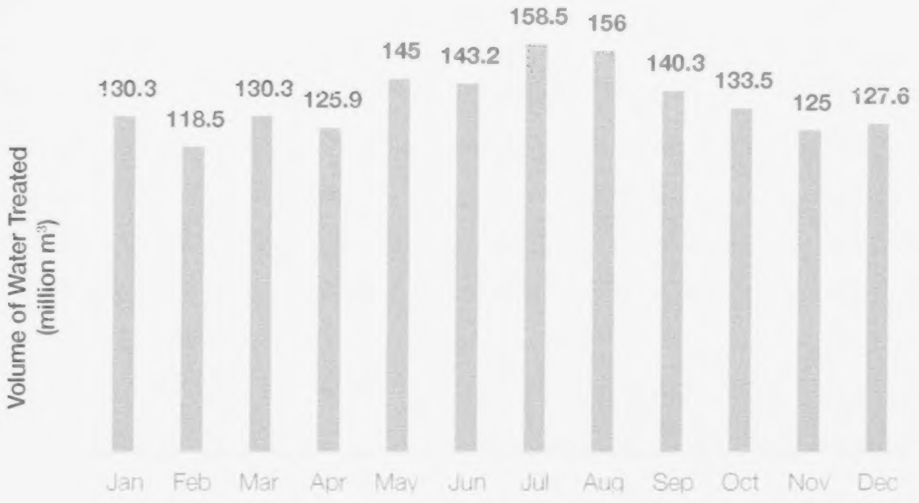

Figure 5.10: Monthly potable water production, Ontario municipal drinking water systems, 2013

Source: Statistics Canada, Table 153-0124 from *Survey of Drinking Water Plants, 2013* (2015).

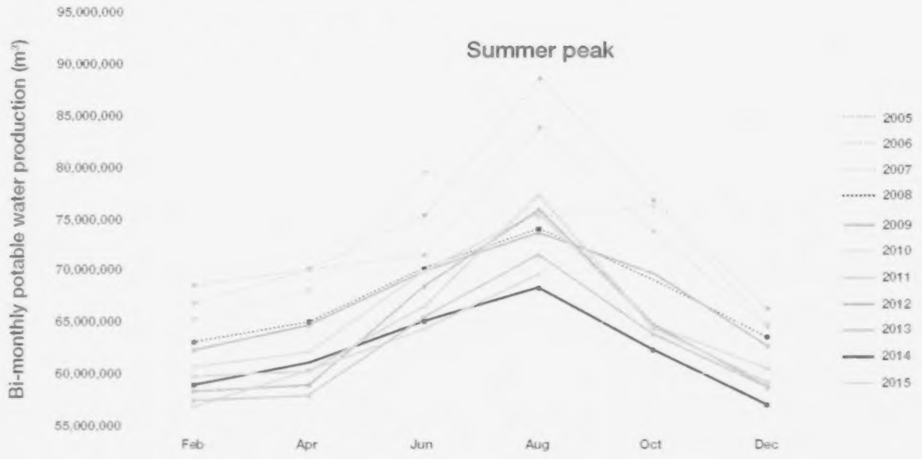

Figure 5.11: Toronto Water potable water production, 2005-2015

Source: City of Toronto

> Reducing summer peak water use can deliver a triple benefit.

The peak in municipal water demand in dry summer conditions usually occurs at the same time as peak agricultural water demand, and as peak water stress in the natural environment, when streamflow rates and soil moisture levels are at their lowest. At such times, increased municipal water use is a further stress on natural ecosystems.

Summer water peaks also bring an infrastructure burden, paralleling the challenges of meeting peak demand in the electricity system.[48] Water system operators must continually keep water supply and demand in balance. Most water systems can absorb minor changes in demand, on the timescale of hours or days, by storing treated water in tanks and reservoirs. For any longer timeframe, water treatment and distribution systems must be sized to meet the summer peak. This means that peak summer water demand is disproportionately expensive to meet.

Thus, reducing summer peak water use can deliver a triple benefit: energy savings, environmental benefits, and reduced infrastructure costs.

What Causes the Peak and How Can We Handle It?

Reducing outdoor water use is more difficult than indoor residential use, and involves more than water-efficient fixtures and appliances. In particular, outdoor water use varies dramatically between households and depends on factors such as landscape design and customer behaviour.

Two studies from the *Outdoor Water Use Reduction Manual*, prepared for the Ontario Water Works Association show how much outdoor water use varies.[49] Water use analysis from Kitchener showed that about 10% of homes were "superusers", who at least double their water use in the summer, while the other 90% had little change in water use in summer months. Superusers might have good opportunities to reduce water use, e.g., by mulching garden soils, increasing soil organic matter, or covering pools when not in use. Another study of 150 households found that households with automatic irrigation systems use ten times as much water as other users. While small, this study suggests that residential and ICI automatic irrigation systems could be an important conservation target.

The province has not used the Ontario Building Code to address outdoor water use, perhaps due to doubts as to whether the Code can or should regulate lot-level practices outside the building envelope. However, on-site sewage systems are already included in the Ontario Code and legally considered part of the building, even if not physically connected. Los Angeles, California, is an example of a jurisdiction that uses its Building Code to address outdoor water use. It mandates covers on swimming pools, restricts use of potable water outdoors, and requires separate metering of indoor and outdoor water use.[50]

Some Ontario municipalities have tackled outdoor water use by:

- **Restricting non-essential outdoor water use**, either all summer or during periods of water stress, e.g., allowing residents to water lawns only on odd/even-numbered days. These bylaws are often weakly enforced.
- **Promoting gardens using plants with lower water requirements, in place of grass lawns**. Peel Region and several other municipalities offer the Fusion Gardening ® program, which offers a free landscaping consultation, and a 20% discount on water-efficient plants. Fusion Gardening ® also emphasizes on-site infiltration, to keep rainwater on-site and reduce runoff. York Region is currently conducting a pilot project in Kleinburg to quantify the water savings from this landscaping approach.
- **Promoting smart irrigation**. York, Halton, and Peel Regions have worked with Landscape Ontario to develop the Water Smart Irrigation Professional program. This training program for contractors

focuses on minimizing water waste in irrigation systems, including leak detection and smart controllers that use weather and/or soil moisture data to minimize overwatering.[51] A pilot project suggests that smart controllers can save 10,000 litres per day per acre of irrigated lawn. York is investigating whether it can mandate smart controllers for ICI facilities with in-ground automatic irrigation systems.[52]

- **Encouraging rainwater harvesting**, i.e., collecting rain in barrels or cisterns at a home or ICI facility. Rain barrels are usually placed at the end of a downspout to capture rainwater and typically collect 100-500 litres of water. This modest storage capacity can reduce stormwater runoff and combined sewer overflows, but may not significantly reduce potable water use for irrigation, for an average residential property.[53]

5.8 ECO Recommendations

To improve the water efficiency of new buildings, MMA should enhance standards for water conservation in the Ontario Building Code. The ECO recommends that the next Building Code address more efficient fixtures, outdoor water use, water metering in multi-unit buildings, and water reuse.

More efficient fixtures: MMA should evaluate tightening water efficiency levels for water fixtures, particularly toilets - to below 4.8lpf for residential buildings, and to 4.8lpf in non-residential buildings.[54]

Outdoor water use: The greatest water conservation benefits, environmental and financial, would come from reducing the summer peak in outdoor water use.

Metering in multi-unit buildings: A significant opportunity for water conservation is missed if units in MURBs are not individually metered, Ontario has already acted to advance metering of individual units for electricity, and should do the same for water.[55] Ontario should use the Ontario Building Code to mandate building plumbing designs that will support metering of individual units, whether through separate utility meters or sub-meters. Some analysis may be required to determine if there are specific building types for which this is not practical.

Water reuse: Given the demonstrated ability of greywater reuse to deliver large water savings, and the lost opportunity if greywater-compatibility is not considered at time of construction, MMA should evaluate mandating greywater-ready plumbing design in the Building Code. The ECO also supports MMA's intention to examine whether to set water quality standards for reclaimed water, which would likely apply to greywater and rainwater. It will be important for such a standard to examine and address legitimate health concerns. However, such a standard could effectively prevent water reuse if it imposes excessive and costly treatment and/or monitoring.

Recommendation: The Ministry of Municipal Affairs should amend the Ontario Building Code to place a greater emphasis on water efficiency and conservation, giving particular consideration to:

- ***Higher efficiency standards for fixtures, particularly toilets;***
- ***Reducing summer peak outdoor water use;***
- ***Ensuring that the plumbing design of multi-unit buildings is compatible with water metering of individual units;***
- ***Expanding opportunities for reuse of greywater and rainwater, including greywater-ready plumbing design.***

More also needs to be done to reduce water use in existing buildings, where water use is much higher than in new buildings. While the ECO is pleased that the Ministry of Energy has recently set point-of-sale energy efficiency standards for clothes washers and dishwashers, it is disappointing that MOECC has no plans to set standards for water fixtures (including toilets), and has not even undertaken any study of potential opportunities.[56] Toilets likely offer the largest opportunity, as they are the one product where models not meeting WaterSense efficiency levels still have significant market share. A number of American states have mandated the stricter 4.8 lpf standard, and there is no obvious reason why Ontario should not do so as well.[57]

More also needs to be done to reduce water use in existing buildings.

Toilets are not the only product where there is an opportunity for stricter water efficiency standards. MOECC should also scan other jurisdictions, particularly California, which passed aggressive standards in 2015 for urinals, faucets and showerheads as well as toilets.[58]

Recommendation: The Ministry of the Environment and Climate Change should set water efficiency standards for toilets that apply at point-of-sale.

The broader public sector should be required to add water consumption in buildings to their energy reports, just as large private buildings are required to do, and preferably through the same Portfolio Manager software (see Chapter 3). They should also be required to integrate water conservation into their energy conservation plans.

The provincial power to mandate water reporting and water conservation plans for the broader public sector is held by a different ministry, and stems from a different statute, than for energy. The *Water Opportunities Act, 2010* falls within the Minister of the Environment and Climate Change's authority for water reporting, whereas the *Green Energy Act, 2009* gives authority to the Minister of Energy to require energy reporting. The difference in authority should not matter to water users, especially if both reports can be filed using the same software, and if both conservation plans are combined.

Recommendation: The Ministry of the Environment and Climate Change should require water use reporting and water conservation plans for all broader public sector organizations and integrate this seamlessly with existing energy reporting requirements.

Given the variation in the value of water conservation across the province, the ECO believes that it makes sense for municipalities to continue to take the lead on voluntary water conservation programs. As mentioned in Chapter 4, however, each municipality should be required to determine the appropriate role for water conservation as part of its asset management plan for its water infrastructure, as was originally envisioned in the *Water Opportunities Act, 2010*.

In addition, cost savings are possible by piggybacking water onto provincial energy conservation programs. For example, the Independent Electricity System Operator and gas utilities are currently developing a whole home energy retrofit program, which will look for both electricity and natural gas savings in existing homes. At almost no incremental cost, this program could also identify water conservation opportunities. However, water conservation initiatives were ruled out of the pilot stage of this program, and a proposal by one local distribution company (Welland Hydro) to include water conservation measures in a whole home retrofit pilot was not approved by the Independent Electricity System Operator.[59] As this program moves past the pilot stage, the decision to exclude water conservation should be reconsidered.

Recommendation: The Independent Electricity System Operator and gas and electric utilities should assess opportunities to integrate delivery of water conservation initiatives with existing energy conservation programs, particularly for whole home retrofits.

Endnotes

1. The proportional energy reduction is slightly less, due to the fact that the energy needed for wastewater treatment depends not only on the volume of water, but on the organic content, which does not decline with water conservation.
2. Statistics Canada, *Potable water volumes processed by drinking water plants, by source water type for Canada, provinces, territories and drainage regions*, Table 153-0105 (Ottawa: Statistics Canada, 2013).
3. Environmental Commissioner of Ontario, "Signs of Stress: Declining Baseflows in Southern Ontario" in *Small Things Matter*, Annual Report 2014/2015 (Toronto: ECO, November 2015) at 88.
4. Environmental Commissioner of Ontario, "Water-Taking: Leave Something for the Fish" in *Losing Our Touch*, Annual Report 2011/2012 Part 2 (Toronto: ECO, October 2012) at 105.
5. Quinte Conservation Authority, News Release, "Level 3 Low Water Condition" (4 August 2016).
6. Dr. Ken Minns, "Ontario's Freshwater Ecosystems and Climate Change: Impacts and Responses" (presentation to Latornell Conference, 15 November 2007).
7. Organization for Economic Cooperation and Development, "Abstractions of freshwater" in *OECD Factbook 2015-2016: Economic, Environmental and Social Statistics* (Paris: OECD Publishing, 2016).
8. Statistics Canada, *Survey of Drinking Water Plants*, Table 1-1 (Ottawa: Statistics Canada, 2015); Statistics Canada, *Industrial Water Survey*, Tables 5-1, 19 and 29 (Ottawa: Statistics Canada, 2013); Statistics Canada, *Agricultural Water Use in Canada*, water consumption data (Ottawa: Statistics Canada, 2013); Statistics Canada, *Population and Dwelling Count Highlight Tables*, 2011 Census (Ottawa: Statistics Canada, 2011).
9. Statistics Canada, *Potable water use by sector and average daily use for Canada, provinces and territories*, Table 153-0127, (Ottawa: Statistics Canada, 2013).
10. United Kingdom Environment Agency, *International comparisons of domestic per capita consumption* (Environment Agency, Bristol, 2008).
11. City of Guelph, *2016 Water Efficiency Strategy Update Version 5* (Guelph: City of Guelph, September 2016) at 10.
12. Statistics Canada, *Potable water volumes processed by drinking water plants, by source water type for Canada, provinces, territories and drainage regions*, Table 153-0105, (Ottawa: Statistics Canada, 2013); Statistics Canada, Population served by drinking water plants, by source water type for Canada, provinces, territories and drainage regions, Table 153-0106, (Ottawa: Statistics Canada, occasional).
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Table: Hypothetical Impact of Water Conservation on Customer Rates and Bills

	Before Water Conservation			**After Water Conservation**		
	Water System Costs ($)					
Fixed	$85			$85		
Variable	$20			$15		
Total	$105			$100 (-5%)		
	Customer Rates and Bills					
	Water Use (m^3)	**Water Rate ($\$/m^3$ of water)**	**Water Bill ($)**	**Water Use (m^3)**	**Water Rate ($\$/m^3$ of water)**	**Water Bill ($)**
User A (conserver)	50	$1.05	$52.50	25	1.33 (+27%)	$33.33 (-37%)
User B (non-conserver)	50	$1.05	$52.50	50	1.33 (+27%)	$66.67 (+27%)

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Chapter 6

Water Reuse

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We spend a lot of money, energy and GHGs treating water.

Why use it only once?

Abstract

Almost all water produced by Ontario municipal water systems is treated to potable standards, used only once, treated again as wastewater and then returned to receiving waterbodies. Since both drinking water treatment and wastewater treatment are energy-intensive, this once-through approach has substantial costs, in money, energy and GHG emissions.

This chapter examines the potential for centralized water reuse – use of partially or completely treated effluent from municipal wastewater treatment plants. Many jurisdictions have extensive water reuse programs, but not Ontario or its 444 municipalities. Ontario municipalities could meet certain site-specific non-potable water needs using treated effluent, thus saving energy, money and GHG emissions, and relieving some seasonal water constraints.

As the lack of clear provincial policies, regulations and standards for water reuse inhibit water reuse, the MOECC should establish appropriate standards.

6.1 Why Reuse Water?

Almost all water produced by Ontario municipal water systems is treated to potable standards, used only once, treated again as wastewater and then returned to receiving waterbodies. Since both drinking water treatment and wastewater treatment are energy-intensive, this once-through approach has substantial costs, in money, energy and GHGs. It can also stress natural water supplies, as shown in Chapter 5.

Once-through water use is neither inevitable nor universal. Across the world, fresh water supplies are under pressure from population growth, climate change and land use changes. Many jurisdictions therefore reuse treated wastewater to stretch their fresh water supplies, including the United States, Spain, Israel and India. Some have seen considerable success, as illustrated in case studies below.

Once-through water use is neither inevitable nor universal.

Aside from water scarcity, energy conservation is another reason to reuse water. As shown in Chapters 2 and 3, significant energy is used to treat and transport water and wastewater. Much of the energy used to treat water to potable standards is wasted, because very little of the treated water is used for purposes that require potable water, such as drinking, cooking and bathing. Water reuse can therefore save energy that would otherwise be used in water treatment, pumping, distribution, and/or wastewater treatment.

Non-traditional water sources, which include water reuse and desalinization, currently satisfy less than 1% of the global water need, but that number is steadily rising.[1] Even countries with a tradition of water abundance are now preparing for water shortages. The United Kingdom, for example, recognized in its *2017 Climate Change Risk Assessment Evidence Report* that climate change and population growth will put greater pressure on water availability, and that its current system of water regulation will require substantial reform.[2] Ontario's water law, which is rooted in English assumptions of abundance, will also require reform.

Very little of the treated water is used for purposes that require potable water.

As shown in Chapter 5, some Ontario municipalities are taking a range of water conservation measures, especially those faced with growing populations, supply constraints, and high capital costs. However, no major municipal water reuse projects are in place in Ontario thus far. Why?

6.2 How to Prepare Water for Reuse

Water reuse can be divided into:

- Decentralized water reuse, where wastewater is reused by a water customer (often after some form of on-site treatment) instead of going into the municipal sewer system; and
- Centralized water reuse, where water is collected through the municipal sewer system, treated to some degree at the municipal wastewater facility, then reused.

This chapter deals with centralized water reuse. Decentralized water systems, e.g., greywater systems or rainwater harvesting, are explored further in the water conservation chapter, Chapter 5.

Figure 6.1 presents how a municipal wastewater treatment plant might incorporate water reuse. The level of treatment required for water reuse will depend on the application of the reused water.

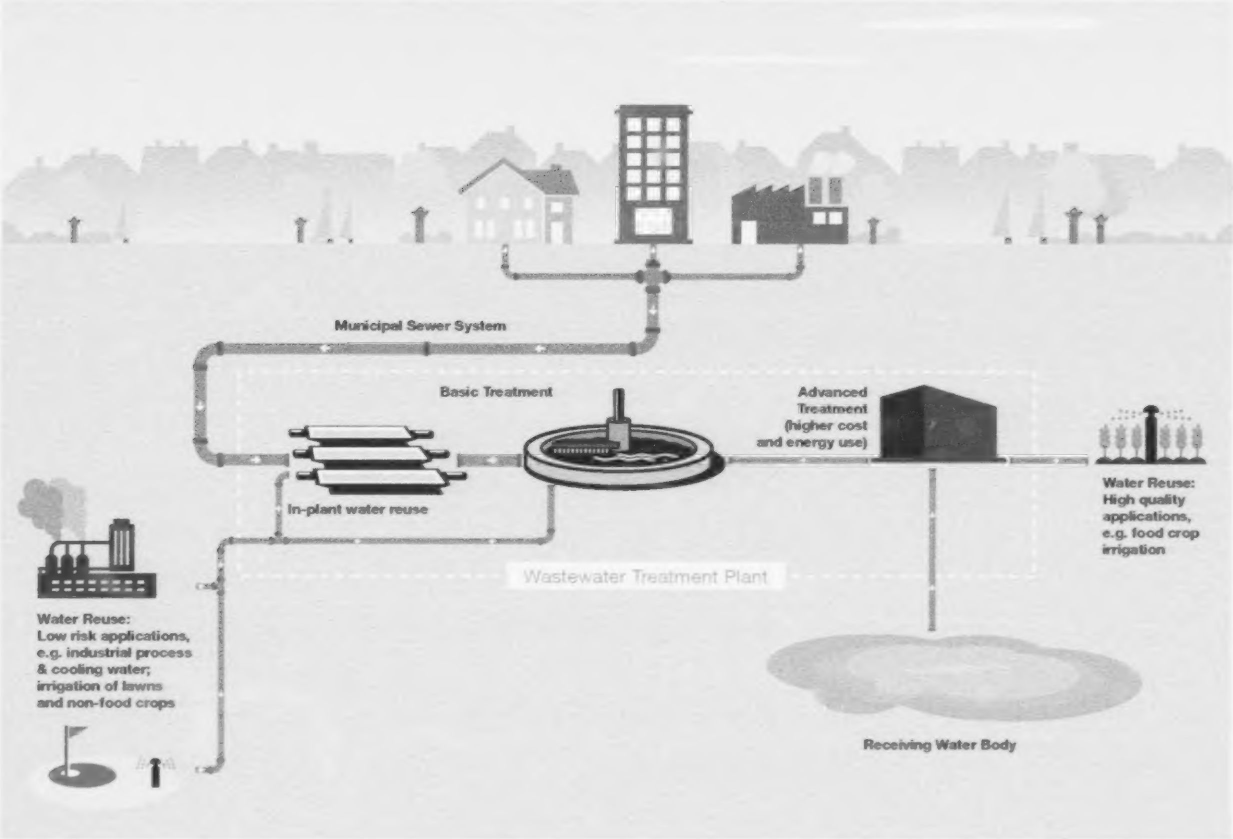
Municipal Sewer System
Basic Treatment
Advanced Treatment (higher cost and energy use)
In-plant water reuse
Water Reuse: High quality applications, e.g. food crop irrigation
Wastewater Treatment Plant
Water Reuse: Low risk applications, e.g. industrial process & cooling water; irrigation of lawns and non-food crops
Receiving Water Body

Figure 6.1. Centralized municipal water reuse

Note: Technologies used in "Basic" and "Advanced" treatment will vary depending on application and jurisdiction. In some water reuse applications (e.g. reuse for drinking water) and jurisdictions, reused water will be treated to a higher quality than water returned to the receiving waterbody, unlike the example shown here.

6.3 What can Non-Potable Water be Used for?

Internationally, irrigation is typically the main application for non-potable reuuse of water.[3] Other potential uses for non-potable reused water include cooling, industrial processes, toilet flushing and replenishing a ground water basin. In Ontario, irrigation of municipal parks and curbside vegetation and toilet flushing could all use reused water if proper standards were in place. Applications for reuse of centrally treated wastewater are location-dependent, and may require dedicated piping for non-potable water distribution. Initial customers may need to be very close to the wastewater plant. Over time, this distribution network could expand opportunistically to add additional locations that can make use of non-potable water. Treatment of wastewater can be customized to meet the water quality requirements of the reuse purpose, e.g., reuse treatment for landscape irrigation can be less rigorous than treatment for food crop irrigation.

Table 6.1 shows how water reuse applications are categorized in U.S. Environmental Protection Agency (EPA) Guidelines:

Table 6.1. Water Reuse Applications

Category of Reuse	Description
Urban Reuse	The use of treated wastewater for non-potable applications in various municipal settings which may or may not have access restrictions by the public, e.g., public toilets, land irrigation
Agricultural	Irrigation of food or non-food crops, depending on the level of treatment of wastewater (food crops would require higher levels of treatment)
Artificial Water Bodies	The reusable water can be used to fill up artificial water bodies which may or may not be used for recreational activities that could lead to human contact
Environmental	Used to create, enhance, sustain or augment natural water bodies such as wetlands and aquatic habitats
Industrial Reuse	Using treated wastewater in industrial processes such as power production, cooling and fossil fuel extraction
Groundwater Reuse	Augmenting a water source that is not used for drinking purposes
Potable Reuse (direct or indirect)	Adding to a drinking water source that may or may not be treated further before becoming of potable quality

Source: Adapted from U.S. Environmental Protection Agency, *2012 Guidelines for Water Reuse*

6.4 Examples of Successful Water Reuse

Shepard Energy Centre, Calgary, Alberta

The City of Calgary depends on the Bow and Elbow Rivers for its fresh water. Faced with a growing population, increased water demand, and a finite and possibly declining supply of freshwater as glaciers retreat, Calgary has a wide range of water efficiency programs.[4] The use of reclaimed water in the Shepard Energy Centre is a leading example.

The Shepard Energy Centre, Alberta's largest natural gas power plant, uses 14 million litres per day of treated effluent from the Bonnybrook Wastewater Treatment Plant instead of potable water.[5] Tertiary treated water is conveyed via a 14 km underground pipeline and is further treated onsite before being used for process and cooling needs.[6]

California

Water reuse has been integral to the economic and population growth of California, since the early 1800s.[7] For Californians, water reuse protects other water supplies, and is considered environmentally responsible. An estimated 826 million m^3 of municipal wastewater is reused every year, with close to 60% of that being used for urban and agricultural irrigation.[8] Other uses include geothermal energy production, groundwater recharge, landscape irrigation, and industrial use.[9] San Francisco, California has recently added water reuse technology to several wastewater treatment plants, and built distribution piping to transport this reclaimed water to irrigate golf courses and city parks.[10]

Water reuse protects other water supplies.

The rules for the treatment, discharge and use of reused water are established by Title 22 of California's Water Recycling Criteria; the California Department of Public Health sets bacteriological and treatment standards for the water. Effluent standards are enforced by nine regional water quality control boards, in consultation with the public health department.[11]

California aims to increase the use of recycled water by 1.2 billion m^3 per year by 2020 and by 2.5 billion m^3 per year by 2030 from its 2002 levels.[12] With California recently experiencing one of its worst recorded droughts, there is strong support for opportunities to reuse water. Over 76% of Californians believe that recycled water should be used routinely, regardless of drought conditions.

California irrigation using recycled water. Source: iStock

6.4.1 California's Title 22

Title 22 of California's Water Recycling Criteria contains California state guidelines for reuse of various levels of treated wastewater.[13] Title 22 requires California Department of Public Health to develop bacteriological and treatment standards for each level. The nine regional water boards, that are part of the State Water Resources Control Board, issue permits for individual water recycling projects in accordance with statewide criteria established by CDPH. Some of the uses for different levels of treated water listed in Title 22 include:

- 40 uses for disinfected tertiary recycled water, such as park irrigation
- 24 uses for disinfected secondary recycled water, such as irrigation of animal feed crops
- 7 uses for undisinfected secondary recycled water, such as industrial uses
- Other allowable uses, such as landscape irrigation, commercial laundry, decorative fountains etc.

Israel

The United Nation's Human Development Report has classified the Middle East as the world's most water-stressed region. Israel's pioneers set out to "make the desert bloom". Thirty years ago, faced with overtaxing its main water sources, the Sea of Gallilee and two aquifers, Israel focussed quickly on water reuse. Almost 80% of the nation's wastewater is now reused, about 400 million cubic metres of wastewater per year, a gold standard for water recycling.[14]

Huge amounts of recycled water are conveyed from urban wastewater plants to farms through a massive network of dedicated purple pipes. The Israel Water Authority prices recycled water at a quarter of the price of potable water. The Water Authority also matches water treatment to its intended use, to minimize waste of energy. Expensive desalinated potable water goes for domestic use. Wastewater undergoes only as much treatment as is needed for the crop or other end use.[15]

It is estimated that treated wastewater will cover 50% of Israel's agricultural needs by 2020, and national policy calls for reclaimed effluents to ultimately be 100% utilized by agriculture. Israel is developing a global standard for reusing wastewater for irrigation.[16] Israel's achievements in wastewater recovery and reuse are so impressive that they were given special mention in the UN World Water Development Report presented in 2009. Several Israeli businesses develop water treatment technologies and the country's export earnings from water-saving technologies is close to $2.2 billion a year.[17]

Drip irrigation technology in Israel using recycled water.
Source: iStock

6.5 Water Reuse in Ontario

Ontario has comparatively abundant water resources, but localized water constraints do occur, especially in areas of rapid population growth and in areas dependent on groundwater. The increasing effects of climate change are also making themselves felt. For example, some parts of Ontario experienced a significant drought in 2016 (see Figure 5.1), with Pearson Airport at Toronto receiving less than half of its average rainfall of 240 mm in July of that year.

As described in Chapter 5, some Ontario municipalities have water conservation strategies, making use of conservation programs, water pricing, water meters and public education to change habits of water users. Municipalities will naturally adopt the most convenient and cost-effective conservation tools first. Reuse of municipal wastewater effluent may be an approach with only niche applications in Ontario in the immediate future. But in the medium or longer-term, water reuse should be part of Ontario's plan to adapt to climate change, and to keep down the energy, financial and environmental cost of water infrastructure.

Some Ontario municipalities have already begun considering water reuse.

Upper York Sewage Solutions

Faced with one of the fastest growing populations in the province and very expensive wastewater effluent requirements to control phosphorus in Lake Simcoe (See Chapter 7), York Region has proposed a water reclamation centre. This plant would be able to treat 40 million litres/day to a high non-potable quality. After treatment (microfiltration, reverse osmosis and UV disinfection), the water could be released into the East Holland River, or reused. Potential uses include irrigation and industrial use, with the potential for different levels of effluent treatment at the wastewater plant depending on the end use.[18] An Environmental Assessment (EA) was filed with the Ministry of the Environment and Climate Change (MOECC) by York Region in 2014. The Ministry received public comments on the EA until February 2016 and is currently considering all the submissions received. The Ministry has not provided a timeline for issuing a decision.[19] York projects that the plant will be completed by 2024.

Meanwhile, York is planning a water reuse research demonstration project using reclaimed water from one of its existing water resource recovery facilities where wastewater is treated. The project will focus on the use of reclaimed water for agriculture uses, such as sod farms, and its impact on plant health, soil properties and water quality and quantity. The project, currently in the expression of interest stage, will take 36 months; energy savings and GHG reductions will be tracked.[20] The region anticipates that the results of this demonstration will inform water reuse plans for the Upper York project.

University of Guelph's Water Reuse Feasibility and Implementation Study

The City of Guelph relies 100% on groundwater for its water supply and has made water conservation a priority since the late 1990s. University of Guelph's Engineering School completed a study in 2005-2006 to explore wastewater reuse options to meet the future population growth in Guelph. It concluded that, within 20 years, the City could reuse 6% of its wastewater for non-potable uses, such as non-crop irrigation and construction site dust control.[21] Though the feasibility study recommends that Guelph undertake more detailed studies to understand the potential of different water reuse initiatives, the study flags the lack of provincial regulations that would guide the municipality on the parameters of proper water treatment and how that water could be reused.[22]

Since the completion of the study, the City of Guelph has supported decentralized water reuse through incentives for rainwater/greywater systems, and a rainwater harvesting system to wash city buses. However, Guelph has recognized that larger-scale, centralized reuse at municipal facilities has greater potential to reduce potable water demand. Guelph's *2016 Water Efficiency Strategy* allocates research funding for centralized water reuse.[23]

6.6 The Lack of Clear Provincial Rules

ECO survey quotes:

"there are currently no clear Provincial guidelines for municipal water reuse that consider reclaimed water a valuable resource. Municipal water reuse could be successful in Ontario with a supporting regulation recognizing it as a resource different than potable water"

- The Regional Municipality of York

"water reuse opportunities continue to be challenging to implement given the lack of clarity around treatment requirements…"

- Town of Oakville

One of the prerequisites for a robust wastewater reuse system is a regulatory framework for water treatment and water reuse. Without it, approvals are difficult to get, and municipalities are concerned regarding liability related to any unintended health or environmental consequence.

Does the MOECC want to see water reuse in Ontario? The signals are mixed. MOECC's *Water and Energy Conservation Guidance Manual for Sewage Works*, February 2011, seems to encourage municipalities to consider water reuse. The manual details the various uses and benefits of water reuse; the importance of water reuse when considering water and wastewater treatment plant upgrades; the factors to consider before implementing a water reclamation initiative; and the need for community support. The manual also details the various options available for using reclaimed water and the factors that will determine those uses. However, the manual also states that there are *"currently no provincial policies or regulations governing water reclamation and reuse in Ontario"*.[24]

Applications for water reuse/reclamation projects are currently considered by the MOECC on a case-by-case basis, which means that water reuse projects face unpredictable approval processes. At best, the application process is similar to the approval process for a new municipal or private sewage works system.[25] For an existing facility, an application to add water reuse reopens the whole Environmental Compliance Approval (ECA), with potentially serious adverse consequences as well as high costs and long delays. In these circumstances, it is not surprising that municipalities will consider water reuse only in extreme cases.

6.7 ECO Recommendations

The current lack of clear provincial policies, regulations and standards is inhibiting water reuse initiatives at the municipal level.

Recommendation: The Ministry of the Environment and Climate Change should establish appropriate standards for water reuse.

The following steps could all encourage water reuse in Ontario:

- Establish a clear definition of reused/recycled water
- Consult with industry experts to begin classification of levels of water quality and its allowable uses
- Identify and evaluate high-benefit/low risk applications for water reuse, such as non-crop irrigation, industrial process or cooling water
- Set up permissive approval processes for pilot studies on water reuse
- Collaborate with volunteer municipalities on water reuse pilot projects, which it has already begun to do with municipalities like York Region
- Recommend monitoring protocols for water reuse pilot projects
- Establish criteria for evaluating the effectiveness, merits and scalability of water reuse projects

- Identify case-specific factors where municipal water reuse may be promising in an Ontario setting, such as:
    - Close proximity to suitably sized, willing end-users (e.g., golf course irrigation or once-through cooling water)
    - Reliance on a seasonally constrained supply of water
    - Situations where an imminent and expensive expansion of a water treatment facility could be avoided by innovative water conservation approaches, including reuse

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Chapter 7

Phosphorus

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We need to reduce the amount of phosphorus going into our lakes.

How can we do it without using too much money and energy?

Abstract

High nutrient levels (particularly phosphorus), climate change (intense rain events and rising temperatures) and land use changes are increasing toxic algal blooms in Ontario's lakes. The main sources of nutrients are agricultural and urban runoff ('non-point sources') and, to a much lesser extent, industrial and municipal wastewater ('point sources'). However, a key element of the province's response to the issue has been to require municipal wastewater facilities to reduce phosphorus effluent levels, in some cases to extremely low levels, significantly increasing capital and operating costs.

Meeting stringent phosphorus effluent standards at wastewater plants sometimes requires energy- and capital-intensive technology, which can be up to **five times more energy intensive** than the next highest treatment level. This can impose a significant energy, financial and greenhouse gas (GHG) burden on municipalities for a very small phosphorus reduction. Much larger reductions of phosphorus from non-point sources could be achieved and verified at a much lower cost in energy, money and GHG emissions.

The Ministry of the Environment and Climate Change should implement phosphorus reduction programs that reduce loadings to sensitive surface waters, in a way that minimizes the energy use, financial costs, and greenhouse gas emissions needed to achieve reductions.

7.1 The Problem: Algal Blooms

Nutrient loadings from human, agricultural and industrial waste, combined with climate change, changes in land use patterns and invasive species are creating toxic algal blooms in Ontario's lakes that are more frequent and more severe (see Figure 7.1).[1]

Lake Erie algal bloom, 2011. Source: ESA Earth Online.

Beyond aesthetic impacts like scum, odour, and taste, algal blooms can also be physically harmful to aquatic life and humans. Excessive algal growth can block sunlight and sap oxygen from deep waters as it decomposes, in some instances causing large fish kills.[2] Some algal blooms also produce toxins that are harmful to human and animal health.[3] For example, blue-green algae produces cyanotoxins which can cause rashes, hives and blisters.[4] Swallowing these toxins can lead to diarrhea, vomiting, liver poisoning and neurotoxicity, with symptoms ranging from numbness and dizziness in humans to convulsions, excessive salivating and death in dogs.[5]

Though nitrogen and phosphorus both contribute to algal blooms, in Ontario, the primary nutrient of concern is phosphorus.[6] In the Great Lakes, overall phosphorus reduction targets are set in an international agreement between Canada and the U.S.[7] How these reductions will be achieved in practice is being determined on a watershed-by-watershed basis. For example, in the case of Lake Erie, Ontario has committed to a 40% reduction by 2025 for its share of loadings to the western and central basins, and an interim goal of a 20% reduction by 2020.[8] Michigan and Ohio have committed to the same phosphorus reduction targets for their share of the loadings to the western basin.[9]

Outside of the Great Lakes, only Lake Simcoe is subject to strict phosphorus reduction targets.[10] Wastewater plants in South Nation watershed in Eastern Ontario are also subject to strict phosphorus limits in any new or amended environmental compliance approval.[11] The strict phosphorus limits imposed on Lake Simcoe and South Nation wastewater plants seem poised to spread across Ontario.

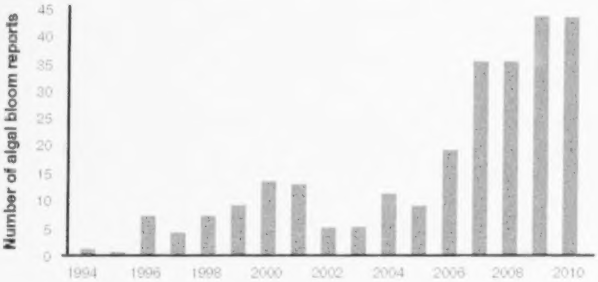

Figure 7.1. Number of algal bloom reports in Ontario (1994-2010)

Source: Jenny Winter, MOECC, *Algae Blooms in Ontario's Lakes: Analyzing the Trends* (2011).

7.2 Wastewater Plants - How Big a Source?

The main sources of phosphorus are agricultural and urban runoff ('non-point sources') and, to a much lesser extent, industrial and municipal wastewater ('point sources'). Though data is not currently available for all waterbodies in Ontario, Lake Simcoe and Lake Erie data illustrates that point sources, primarily wastewater treatment plants, represent around 7-12% of phosphorus loadings (see Figures 7.2 and 7.3).

The ECO will consider potential improvements to the province's treatment of non-point sources of phosphorus in our 2016/2017 Environmental Protection Report.

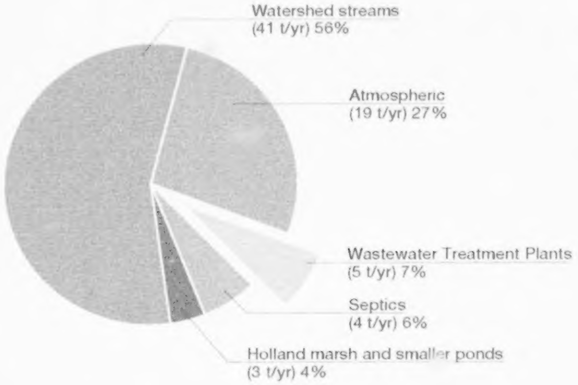

Figure 7.2. Lake Simcoe phosphorus sources (2002-2007)

Source: Ministry of the Environment and Climate Change, *Lake Simcoe Phosphorus Reduction Strategy* (2010) Figure 4.

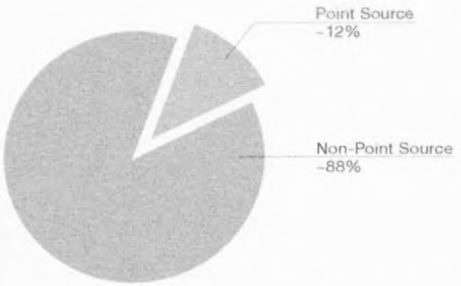

Figure 7.3. Phosphorus sources, Lake Erie

Note: "Point source" includes industrial wastewater discharges in addition to municipal wastewater plants, and is estimated to be between 10-15%.

Source: Ministry of the Environment and Climate Change, *Reducing Phosphorus to Minimize Algal Blooms in Lake Erie*, policy proposal (2016).

7.3 Wastewater Discharge Limits - How Stringent?

Although Ontario wastewater treatment plants contribute only a small percentage of the total phosphorus problem, they have been responsible to date for a disproportionate share of phosphorus reductions.

This may be because municipal wastewater plants are the easiest and most convenient sources for the MOECC to regulate. Wastewater plants are prominent point sources that can be reliably monitored and which cannot operate without discretionary provincial approvals under the *Ontario Water Resources Act*. It is therefore relatively straightforward for the MOECC to set, monitor, verify, and tighten, limits on municipal wastewater plant phosphorus discharges.

Per the MOECC *Guidelines for Sewage Works*, the "normal" level of wastewater treatment is secondary or equivalent. (For a general description of wastewater treatment processes and their energy demand, see Chapter 2.) "Secondary" means, among other things, that wastewater plant effluent must not exceed a monthly average concentration[12] of 1 mg/l of phosphorus.[13] For some plants, the MOECC sets more stringent effluent limits, depending on the receiving water body, watershed-specific regulations or policies, and the municipality's ability to fund the necessary treatment technologies.[14] Algal blooms are a major water quality issue driving more stringent standards.

Stringent wastewater effluent standards are both necessary and appropriate.[15] In sensitive watersheds (e.g., those with chronic nutrient loading problems), as the population (and effluent quantity) increases, allowable effluent **concentrations** must drop, just to keep total phosphorus **loadings** stable.[16] As a result, wastewater facilities may be required to meet stricter (lower) effluent concentrations that will either require additional chemical inputs during secondary treatment (to increase coagulation),[17] upgrading to tertiary treatment, and in some limited instances, quaternary treatment. Phosphorus effluent concentrations typically achievable with different levels of treatment are shown in Table 7.1.

The Lake Simcoe watershed offers a textbook case of persistently high phosphorus loadings, contributed predominantly by a variety of dispersed, or non-point sources such as agricultural and urban stormwater runoff (see Figure 7.2).[18] The ministry has long required very stringent effluent quality from the wastewater facilities in this watershed, which collectively contribute only about 7% of the phosphorus load.[19] From the 1980s to 2014, these facilities reduced their phosphorus loadings to the lake by 30 tonnes.[20]

In 2012 the Environmental Compliance Approvals (ECAs) for all of Lake Simcoe's wastewater treatment plants were amended to include more stringent phosphorus limits.[21] By 2014 about two-thirds of the 15 wastewater treatment plants feeding into Lake Simcoe (directly or indirectly) were consistently achieving tertiary treatment phosphorus effluent levels (≤ 0.1 mg/l).[22] However, this strategy has reached the stage of declining returns. From 2010 to 2014, less than 1 tonne of reductions (of the 44 tonnes in reductions needed by 2045) in phosphorus loadings resulted from these amended ECAs.[23] Nonetheless, these limits do play an important role in preventing future loading increases from these point sources as populations grow.

7.4 High Cost for Little Benefit?

Driving down phosphorus from wastewater treatment plants to extremely low levels is not always good public policy. In the Lake Simcoe watershed, the MOECC now imposes phosphorus concentration and loading caps on some wastewater treatment facilities that require them to achieve less than 0.05 mg/l of phosphorus in monthly average effluent. These caps will disproportionately drive up costs, for example, at the proposed Upper York Water Reclamation Facility (Lake Simcoe watershed) and the Midhurst Wastewater Treatment Plant (Nottawasaga River/Georgian Bay watershed), out of proportion to their environmental benefit.[24]

To meet this standard, York Region's proposed wastewater facility, the Upper York Water Reclamation Facility, will use reverse osmosis technology.[25] This technology, which is also used to desalinate sea water, requires a substantial amount of electricity to pressurize wastewater through a very fine filter (see Table 7.1).

The Midhurst plant is proposing advanced tertiary treatment via membrane filtration (also energy intensive), in combination with additional chemical inputs to increase coagulation of phosphorus in the secondary treatment phase, to achieve its phosphorus standards.[26]

The cost of removing a kilogram of phosphorus from wastewater effluent jumps from about $45,000 at tertiary treatment levels, to about $100,000 per kilogram at quaternary treatment levels (see Table 7.2).[27] A significant part of the increased costs are due to the additional energy use required by these systems, which can use as much as five times more energy (see Table 7.1). According to York, its newest wastewater treatment plant will require more than 3,000 kWh per million litres treated. For comparison, the Duffin Creek treatment plant, which currently treats the majority of York's wastewater and discharges into Lake Ontario, has an energy intensity of approximately 500 kWh per million litres.[28] However, the Duffin Creek plant, which treats effluent to a phosphorus concentration of 0.5 mg/l, has come under fire from the Mayor of Ajax for potentially contributing to nearshore growth of algae in Lake Ontario.[29] It is possible that Duffin Creek may become subject to more stringent effluent limits in the near future.

The additional energy used for advanced wastewater treatment is primarily electricity. Ninety percent of Ontario's electricity generation has low GHG emissions,[30] but electricity used at peak times of day and peak seasons may be gas-fired. Gas-fired electricity produces about 5 Mt of Ontario's greenhouse gas emissions each year (about 3% of total emissions).[31]

In contrast, removing a kilogram of phosphorus from non-point sources (e.g., agriculture and urban runoff) costs much less, between $4-$1,700 (see Table 7.2), with little-to-no energy consumption or GHGs.

Table 7.1. Range of Achievable Phosphorus Levels and Energy Intensity of Primary, Secondary, Tertiary, and Quaternary Wastewater Treatment Facilities

Treatment Process	Achievable Phosphorus levels (mg/l)	Energy Intensity (kWh per 1000 m³) -Each step is cumulative-
Secondary	0.5 – 1	372 - 450
Tertiary	0.05 – 0.5	400 - 3000
Quaternary (reverse osmosis)	<0.05	1500 - 2000

Source: Adapted from York Region, 2016; MOECC, 2016[32]

Note: In this table, advanced filtration processes are included under Tertiary, and are required before reverse osmosis in the case of a proposed quaternary treatment plant in northern York Region.

Table 7.2. Cost per Kilogram of Phosphorus Removal for Lake Simcoe

Quaternary (reverse osmosis)	$100,000
Tertiary (membrane)	$45,000
Stormwater retrofits	$990 - $1,700
Agricultural Best Management Practices	$4- $270

Source: York Region (2016); Lake Simcoe Region Conservation Authority, *Lake Simcoe Phosphorus Offsetting Program Report* (2014), appendices.[33]

7.5 Or Less Cost for More Benefit?

Good public policy would focus on the cheapest available phosphorus reductions, not the most expensive ones. **Why spend $100,000 removing 1 kg of phosphorus from wastewater effluent, if the same money could reduce 50 to 25,000 kg of phosphorus from non-point sources discharging into the same lake?** And the province does our lakes no favours when it forces municipalities to increase their GHG emissions, which contribute to the warming that will harm those very lakes.

In 2010, MOECC acknowledged that (based on available technology) it may be impractical to drive wastewater phosphorus effluent levels in Lake Simcoe to the limits necessary to achieve their share of the 40% reductions.[34] In such cases, MOECC occasionally permits municipalities to reduce watershed phosphorus loadings from non-point sources instead. This approach, called phosphorus offsetting (see Textbox 7.5.1), deserves much more widespread use, and needs to be supported under a provincial framework for implementation, accounting and verification if it is to be effective on a watershed basis.

Ontario has legislation in place that creates regulation-making for phosphorus offsetting; the relevant section of the Act (*Ontario Water Resources Act*, s.75(1.7)) has recently been proclaimed and will come into force on July 1, 2017. It is unclear if this means that MOECC will soon develop a regulation under this authority.

7.5.1 Phosphorus Offsetting

Phosphorus offsetting is a type of pollution "cap and trade" system used to reduce the cost of pollution control. It allows a wastewater plant to pay non-point sources to reduce their phosphorus discharges into the same watershed, instead of or in addition to driving down phosphorus in plant effluent. This can make sense when non-point sources can reduce the same pollutant much more cheaply, as shown in Table 7.2.

The impact of phosphorus on algal blooms depends both on the total amount discharged, and on local concentrations at hotspots (e.g., areas that are shallow, narrow or confined).[35] Offsetting can be good at reducing the total amount discharged, but strict point source limits may still be necessary to prevent hotspots. In addition, as non-point source phosphorus reductions can be challenging to monitor and verify, offset ratios create a safety buffer: two or more kilograms of reduction from non-point sources in exchange for each kilogram of relief granted to a wastewater treatment plant. A successful phosphorus offsetting scheme therefore includes:

- point source controls where appropriate,
- appropriate offsetting ratios, and
- adequate monitoring and verification to ensure claimed reductions.[36]

Currently, MOECC permits phosphorus offsetting for two wastewater facilities (in New Tecumseth and in South Nation). MOECC is also in the early stages of piloting a phosphorus offsetting program for the Lake Simcoe watershed.[37]

The South Nation watershed has Ontario's longest standing phosphorus offsetting program. It was established in 1998 because the South Nation River had phosphorus levels substantially above provincial standards, which resulted in new or expanded wastewater facilities having to meet onerous phosphorus limits.[38] Meanwhile, about 90% of phosphorus loadings to the watershed were from non-point sources, primarily agriculture. At the time, the region forecasted that meeting the new effluent limits would cost wastewater facilities over $5,000 per kilogram of phosphorus removed versus only $400 per kilogram of phosphorus removed from non-point agricultural sources via best management practices (including staff time, water quality monitoring, reporting, construction costs, etc.).[40]

Administration responsibilities (including monitoring and verification) have been contracted out to South Nation Conservation Authority (SNCA), which also bears the legal burden of delivering the phosphorus reductions.[41] Municipal wastewater facilities purchase offsets from the SNCA, which then issues grants to rural landowners who wish to undertake phosphorus reduction activities. Eligible phosphorus reduction activities include building manure storage facilities and installing livestock fencing along watercourses.[42]

As this was the first offsetting program of its kind in Ontario, and MOECC was concerned about the certainty of non-point source reductions, an offset ratio of 4:1 was established. This program is still in place today and considered a success.

York Region has proposed a phosphorus offsetting program for its planned Upper York Sewage Solutions facility.[43] It includes retrofits to seven existing stormwater ponds to maximize phosphorus capture, construction of a new pond, and installing Low Impact Development technologies within an existing stormwater catchment area.[44] These projects are intended to offset phosphorus loadings from the new wastewater facility's effluent. Based on an offset ratio of 3:1, the proposed offsets are expected to result in net reductions of 336 kg of phosphorus per year.[45] If approved, this program would be administered by the municipality itself, rather than the local conservation authority.

7.6 Lake Erie and Beyond?

MOECC has not developed a province-wide policy that enables municipal wastewater treatment plants to use phosphorus offsetting to meet potentially more stringent effluent standards going forward. They have, however, approved offsetting on a case-by-case basis. This seems short-sighted. Because of Ontario's ambitious greenhouse gas reduction targets, and because climate change worsens algae blooms, MOECC should develop innovative means to meet phosphorus reduction targets without increasing energy consumption and GHG emissions.

In the longer run, the same issues may apply on other lakes, including Lake Ontario. Increasingly stringent phosphorus reductions standards seem inevitable as populations grow around stressed waterbodies. Municipalities are monitoring MOECC's actions and taking into account the possibility of stricter limits at some point in the future. This could have significant energy, cost and GHG impacts, given the large volume of wastewater treated by facilities on Lake Ontario.

7.7 ECO Recommendations

Recommendation: The Ministry of the Environment and Climate Change should implement phosphorus reduction programs that reduce loadings to sensitive surface waters, in a way that minimizes the energy use, financial costs, and greenhouse gas emissions needed to achieve reductions.

Endnotes

1. For a brief description of how nutrient loadings result in harmful algal blooms, see: Canadian Council of Ministers of the Environment, Municipal Wastewater Effluent Development Committee, *Municipal Wastewater Effluent in Canada* (CCME, 2006) at 2; For previous ECO articles on algal blooms, see: Environmental Commissioner of Ontario, "The Environment Impacts of Sewage Treatment Plant Effluent" in *Choosing our Legacy*, Annual Report to the Legislature 2002/03 (Toronto: ECO, 2003); Environmental Commissioner of Ontario, "A New Regulation for Greenhouse Wastewater" in *Small Things Matter*, ECO Annual Report, 2014-15 (Toronto: ECO, 2015).
2. "Frequently Asked Questions: Harmful Algal Blooms", online: National Oceanic and Atmospheric Administration- Great Lakes Environmental Research Laboratory, <www.glerl.noaa.gov//[illegible]/HABs_and_Hypoxia/faq.html>. [Accessed 27 April 2017]
3. *Ibid.*
4. *Ibid.*
5. *Ibid.*
6. "Phosphorus and Excess Algal Growth", modified 17 February 2017, online: Environment and Climate Change Canada <www.ec.gc.ca/grandslacs-greatlakes/default.asp?lang=En&n=6201FD24-1#a2>.
7. *Great Lakes Water Quality Agreement.*
8. *Great Lakes Protection Act, 2015*, SO 2015, c 24, s 9(2); Canada and the United States have committed to develop phosphorus loading reduction strategies and domestic action plans for Lake Erie by 2018. See: Canadian and U.S. government, *2016 Progress Report of the Parties Pursuant to the Canada-United States Great Lakes Water Quality Agreement* (Canada & US, 2016) at 35.
9. The Western Basin of Lake Erie Collaborative Agreement with the States of Michigan and Ohio, signed 13 June 2015.
10. Ministry of the Environment and Climate Change, *Lake Simcoe Phosphorus Reduction Strategy* (Toronto: MOECC, 2010).
11. Dennis O'Grady, South Nation Conservation *"Socio-Political Conditions for Successful Water Quality Trading in the South Nation River Watershed"* (presentation to the Workshop on Evaluation of Agri-Environmental Policies, Braunschweig, Germany, 20-22 June 2011) at slide 8, online: <www.oecd.org/tad/sustainable-agriculture/48170312.pdf>.
12. "Phosphorus concentration" means the level of phosphorus in effluent at any point in time. "Phosphorus load" means the overall mass of phosphorus being released into a waterbody over a certain period of time (typically measured on an annual basis).
13. Ministry of the Environment, *Design Guidelines for Sewage Works* (Toronto: MOECC, 2008) at 8-7.
14. Meeting with MOECC (2017); Ministry of the Environment, *Design Guidelines for Sewage Works* (Toronto: MOECC, 2008) at 15-3.
15. Environmental Commissioner of Ontario, "4.1 Sewage Treatment: Not good Enough" in Redefining Conservation, 2009/10 Annual Report (Toronto: ECO, 2010).
16. For example, Ontario's *Lake Simcoe Protection Act, 2008* led to the establishment of the Lake Simcoe Protection Plan in June 2009. One of the targets identified in the Plan is reducing annual phosphorus loading to 44 tonnes. The Lake Simcoe Phosphorus Reduction Strategy outlines how proportional reductions will be achieved from major contributing sources of phosphorus. The strategy provides a baseline compliance load for each Water Pollution Control Plant starting in 2015.
17. Ministry of the Environment, *Design Guidelines for Sewage Works* (Toronto: MOECC, 2008) at 15.8-7.
18. Ministry of the Environment and Climate Change, *Lake Simcoe Phosphorus Reduction Strategy* (Toronto: MOECC, 2010) Figure 1.
19. Environmental Commissioner of Ontario, "4.3 Lake Simcoe Phosphorus Reduction Strategy: Is it Enough?" in *Engaging Solutions*, 2010/2011 Annual Report (Toronto: ECO, 2011) at 65.
20. Ministry of the Environment and Climate Change, *Minister's Five Year Report on Lake Simcoe: To protect and restore the ecological health of the Lake Simcoe watershed* (Toronto: MOECC, October 2015) online: <www.ontario.ca/page/ministers-five-year-report-lake-simcoe-protect-and-restore-ecological-health-lake-simcoe-watershed>.
21. *Ibid.*
22. Lake Simcoe Region Conservation Authority, *Lake Simcoe Phosphorus Offset Program* by XCG Consultants Ltd. (LSCA, 11 August 2014) Appendix A, at 15; As of June 2015, all STPs in the watershed are in compliance with their ECAs, including their annual phosphorus limits. The ministry continues to work with municipalities to ensure compliance post-2015. See: *Ministry of the Environment and Climate Change, Minister's Five Year Report on Lake Simcoe: To protect and restore the ecological health of the Lake Simcoe watershed* (Toronto: MOECC, October 2015).
23. Ministry of the Environment and Climate Change, *Minister's Five Year Report on Lake Simcoe: To protect and restore the ecological health of the Lake Simcoe watershed* (Toronto: MOECC, October 2015) Table 1.
24. For wastewater plants, see: Township of Springwater, *Evaluations of Treatment Alternatives for Midhurst Wastewater Treatment Plant – Draft, Class EA Phase 3 & 4 for the Midhurst Secondary Plan* by Black & Veatch (Township of Springwater, June 2016) Table 3-3, at 5; For Upper York Sewage Solutions, see: Ministry of the Environment and Climate Change, *Ministry review of the Upper York Sewage Solutions Environmental Assessment* (Toronto: MOECC, 25 July 2014) online: <www.ontario.ca/page/ministry-review-upper-york-sewage-solutions-environmental-assessment>.
25. Ministry of the Environment and Climate Change, *Ministry review of the Upper York Sewage Solutions Environmental Assessment* (Toronto: MOECC, 25 July 2014) online: <www.ontario.ca/page/ministry-review-upper-york-sewage-solutions-environmental-assessment>.
26. Ainsley Group, *Status Update of Class EA to Midhurst Council* (August 2016) online: <www.springwater.ca/cms/one.aspx?pageId=4779649>.
27. Based on a combination of capital and operating costs (XGC, *Lake Simcoe Phosphorus Offset Program Summary Report* (Lake Simcoe Conservation Authority) Appendix A, P.114 -115, www.lsrca.on.ca/Shared%20Documents/reports/offset-program.pdf)

28. In 2012, the Duffin Creek facility treated 119,179 million litres of water using 61,212,782 kWh of electricity, for an energy use intensity of 514 kWh/million litres. See: Regional Municipality of Durham, *Energy Conservation and Demand Management Plan 2014 to 2019* (Durham, nd) at 34.

29. Keith Gilligan, "Durham must study phosphorus reduction at Pickering sewage plant" *Ajax News* (11 May 2016) online: <www.durhamregion.com/news-story/6530485-durham-must-study-phosphorus-reduction-at-pickering-sewage-plant/>.

30. Environmental Commissioner of Ontario, Conservation: *Let's Get Serious*, 2015/2016 Energy Conservation Report (Toronto: ECO, 2016) Figure 2.11.

31. Environment and Climate Change Canada, *National Inventory Report 1990-2014: Greenhouse Gas Sources and Sinks in Canada*, Part 3 (Ottawa: ECCC, 2017) Table A12-7.

32. Based on:

    - Ministry of the Environment and Climate Change, *Water and Energy Conservation Guidance Manual for Sewage Works* (Toronto: MOECC, 2011) at 4.5.4. and 63;
    - Analysis by York Region per Water Environment Foundation, *Manual of Practice #8*;
    - Tertiary treatment energy use estimate based on operating pressure of 7 - 700 kPa;
    - Quaternary treatment energy use estimate based on operating pressures of 1,200 kPa and 1,800 kPa, respectively; and
    - Canadian Council of Ministers of the Environment, Municipal Wastewater Effluent Development Committee, *Municipal Wastewater Effluent in Canada* (CCME, 2006) at 7, online: <www.ccme.ca/files/Resources/municipal_wastewater_efflent/mwwe_general_backgrounder_e.pdf>

33. Lake Simcoe Region Conservation Authority, *Lake Simcoe Phosphorus Offset Program* by XCG Consultants Ltd. (LSCA, 11 August 2014) Appendix A at 21 (re: stormwater), 18 (re: agriculture BMPs). Date for tertiary and quaternary treatment provided by York Region (2016).

34. Ministry of the Environment and Climate Change, *Lake Simcoe Phosphorus Reduction Strategy* (Toronto: MOECC, 2010) at 24-25.

35. "Nutrient Pollution, Where this Occurs: Coasts and Bays", online: United States, Environmental Protection Agency, <www.epa.gov/nutrientpollution/where-occurs-coasts-and-bays>. [Accessed 11 April 2017]

36. Suzie Greenhalgh and Mindy Selman, "Comparing Water Quality Trading Programs" (2012) 42:2 JRAP 104 at 111, online: <www.jrap-journal.org/pastvolumes/2010/v42/v42_n2_a2_greenhalgh_selman.pdf>. ('Water quality trading' is an umbrella terms which captures phosphorus trading).

37. Mike Walters, Lake Simcoe Region Conservation Authority, "Phosphorus Offsetting Program" (presentation to Latornell Conference, 17 November 2015) online: <www.latornell.ca/wp-content/uploads/files/presentations/2015/Latornell_2015_T2H_Mike_Walters.pdf>.

38. Dennis O'Grady, South Nation Conservation *"Socio-Political Conditions for Successful Water Quality Trading in the South Nation River Watershed"* (presentation to the Workshop on Evaluation of Agri-Environmental Policies, Braunschweig, Germany, 20-22 June 2011) at slide 8, online: <www.oecd.org/tad/sustainable-agriculture/48170312.pdf>.

39. *Ibid* at slide 3.

40. *Ibid* at slide 2.

41. *Ibid* at slide 13.

42. Rhonda Boutz, South Nation Conservation Authority, *Total Phosphorus Management Program* (presentation made to the Environmental Commissioner of Ontario, May 2017) at slide 9.

43. Ministry of the Environment and Climate Change, *Ministry review of the Upper York Sewage Solutions Environmental Assessment* (Toronto: MOECC, 25 July 2014) online: <www.ontario.ca/page/ministry-review-upper-york-sewage-solutions-environmental-assessment>.

44. *Ibid.*

45. York Region, Environmental Services, "Upper York Sewage Solutions (UYSS) Project Status Update" (presentation to Lake Simcoe Region Conservation Authority Board of Directors' Meeting, 25 November 2016) online: <www.lsrca.on.ca/Shared%20Documents/board/presentation_nov_2016_UYSSStatusUpdateLSRCABODPresentation_20161125.pdf>.

Chapter 8

Energy from Sewage

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There's a lot of energy (and GHGs) in wastewater

Why not turn sewage plants into energy centres?

Abstract

The organic material in wastewater is a valuable source of energy that is currently mostly wasted. It produces both carbon dioxide and methane, which is an even more powerful greenhouse gas.

Anaerobic digestion is a proven technology to produce and capture methane from such organic material. This biogas, following clean-up, can be burned for on-site heating or combined heat and power, used as a fuel for fleets, or injected into the local natural gas utility pipelines as renewable natural gas.

Most Ontario wastewater treatment plants do not use anaerobic digestion. Of those that do, the majority flare (and thus waste) at least some of the energy. To achieve Ontario's goal of reducing greenhouse gas emissions, anaerobic digestion and energy recovery should become standard at wastewater treatment plants whenever practical. Even better, treatment plants could become "energy centres" that also produce and capture methane from a wide range of supplemental organic wastes. Keeping organic wastes out of landfills is essential to Ontario's circular economy strategy, and capturing the methane from such wastes is important for meeting climate targets.

This opportunity will be challenging to realize, but it offers so many benefits that it deserves focused government attention and support.

8.1 What is Biogas and How is it Produced?

Sewage contains organic material, including human body waste, food waste, soaps, etc. Much of this material is eventually broken down by bacteria into the two most common greenhouse gases (GHGs), methane and/or carbon dioxide. Generally speaking, aerobic conditions produce carbon dioxide and anaerobic environments produce methane.

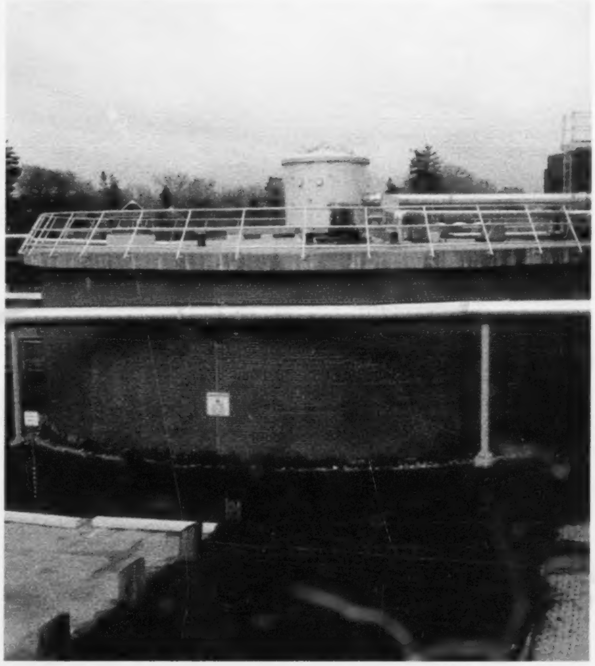
At the wastewater treatment plant (WWTP), some of the organic matter in sewage is converted to carbon dioxide as part of secondary (aerobic) wastewater treatment. However, the majority of the organic matter is separated from the wastewater stream into a semi-solid sludge that requires further treatment.

> Sewage contains organic material that opens up possibilities for energy recovery.

At this stage, **anaerobic digestion** (AD) can be used to treat the sludge. Anaerobic digestion occurs in a closed vessel that excludes oxygen. It converts 50% - 60% of the biodegradable organic material to biogas, and creates a smaller volume of residual sludge.[1] The primary purpose of AD has traditionally been to reduce the volume of treated sludge produced, and therefore the cost of disposal.[2]

However, AD also opens up possibilities for energy recovery. The **biogas** it produces typically contains 55%-75% methane and 24% - 44% carbon dioxide, with 1% or less of other gases.[3] Biogas typically has an energy content of about 22 megajoules per cubic metre,[4] essentially all of it from methane.

Ontario wastewater plants with AD often flare this gas (burn it without energy recovery). This is better from an emissions perspective than releasing unburned biogas to the air, but is still a waste of potentially useful energy. In a circular economy, biogas could displace fossil fuels, e.g., for on-site heating, electricity generation, injection into the natural gas pipelines, or in natural gas vehicles (see Figure 8.1).



Anaerobic digester at City of Barrie Wastewater Treatment Facility. Source: City of Barrie.

Additional processing is required for some of these applications. For example, prior to injection into natural gas pipelines (an option for plants adjacent to the natural gas system), impurities such as siloxanes, carbon dioxide, water and hydrogen sulphide must be removed. This cleaned gas, which meets pipeline quality specifications, is often referred to as "renewable natural gas" (RNG) or "green gas".[5]

> In a circular economy, biogas could displace fossil fuels.

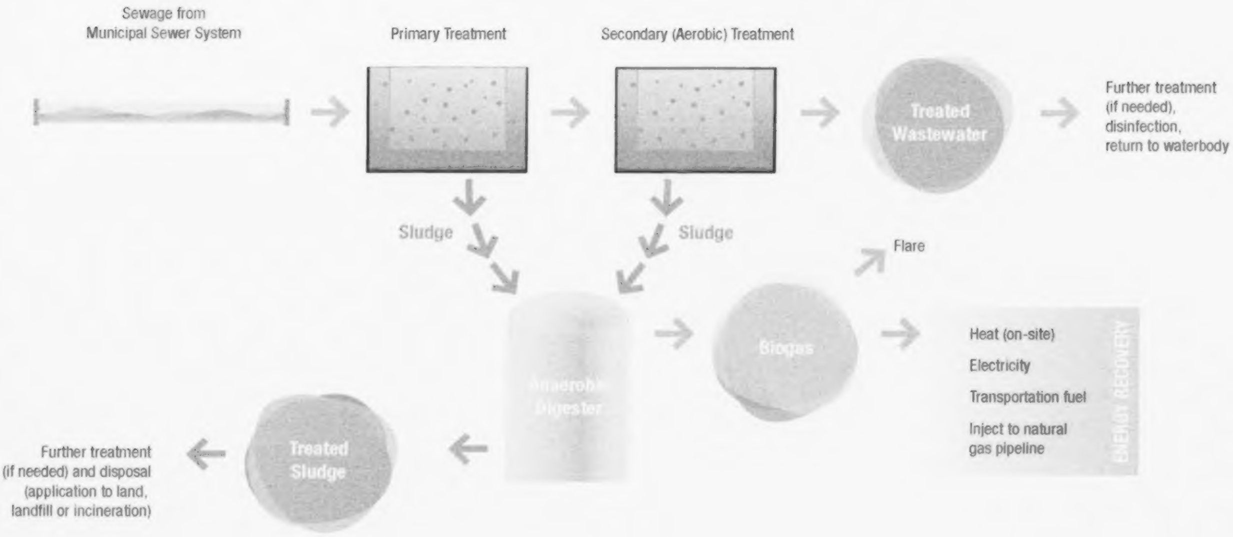

Sewage from Municipal Sewer System
Primary Treatment
Secondary (Aerobic) Treatment
Treated Wastewater
Further treatment (if needed), disinfection, return to waterbody
Sludge
Sludge
Flare
Anaerobic Digester
Biogas
Heat (on-site)
Electricity
Transportation fuel
Inject to natural gas pipeline
ENERGY RECOVERY
Treated Sludge
Further treatment (if needed) and disposal (application to land, landfill or incineration)

Figure 8.1. Anaerobic digestion and energy recovery from wastewater treatment

Only a minority of Ontario municipal wastewater treatment plants currently use anaerobic digestion for their sludge (about 30% from the ECO survey). If anaerobic digestion is not used, the organic material in sludge will eventually break down into carbon dioxide or, worse, methane, producing greenhouse gas emissions without any useful energy recovery. This can occur on-site or off-site, e.g., at landfills.

8.2 How Much Biogas Potential is There in Ontario?

The amount of usable methane generated by a WWTP will vary with the amount of biodegradable organic material it processes. Wastewater contains roughly three times the energy required to treat it (depending on the sewage source and the required level of treatment) although not all of this energy can be recovered.[6]

In some European countries, biogas from wastewater plants has become an important energy source. Biogas production from WWTPs contributes approximately 20% of all biogas used for energy in Denmark, and as high as 40% in Sweden.[7]

Research by the Canadian Biogas Association suggests an Ontario potential of approximately 0.0336 m^3 methane per cubic metre of wastewater.[8] A report by Alberta Innovates[9] for Enbridge Gas Distribution and Union Gas estimates that Ontario treats about 2 billion m^3 of municipal sewage per year, giving an estimate of 68 million m^3/year as the potential for Ontario municipal sewage to produce RNG through anaerobic digestion. The report also estimates that an additional 69 million m^3/year of methane potential exists from gasification of the residual bio-solids, although this is likely not feasible in the near-term.[10]

Anaerobic digestion of other organic wastes could provide much larger amounts of RNG. Alberta Innovates estimates a near-term Ontario potential of 1,372 million m^3/year (20 times the volume from WWTP alone), from livestock manure, crop residues, organics in municipal solid waste, WWTPs and landfill gas.[11] This is roughly 6% of the total volume of natural gas supplied to Ontario customers, and could reduce GHG emissions by about 2.7 Mt/year carbon dioxide equivalent (CO_{2eq}), roughly 2% of provincial emissions.[12] Some of these biogas sources, particularly crop residues and organics in municipal solid waste, are potentially well-suited to co-digestion at WWTPs, as discussed below.

The potential contribution of RNG in Ontario from all sources is shown in Figure 8.2 below.

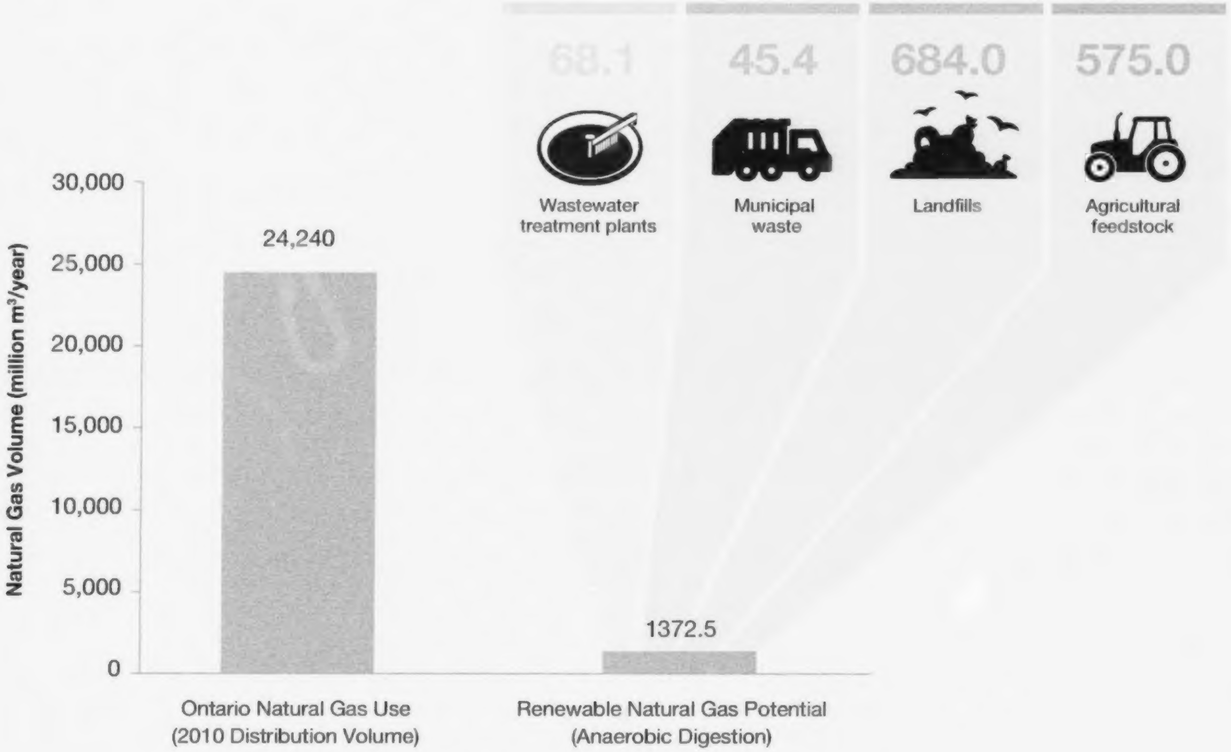


Figure 8.2. Ontario potential for renewable natural gas production (by feedstock) compared to 2010 natural gas distribution

Note: Excludes longer-term potential for additional renewable natural gas production from gasification technology, including gasification of bio-solids remaining after anaerobic digestion.

Source: Enbridge Gas Distribution (2011)[13].

8.3 Energy Recovery in Ontario Wastewater Plants

In Ontario, there are some 750 WWTPs, all of which have some potential to generate biogas. However, according to the ECO's Water-Energy Efficiency Survey (2017) (see Textbox 1.4.1 and Appendix A), few municipalities recover biogas for energy production from wastewater.

About 30% of respondents (28 in total) indicated that they use anaerobic digestion as part of their wastewater treatment processes. These municipalities use the biogas for the following uses (multiple uses are possible, so the totals do not add to 100%):

- 68% flare at least some of the methane produced, with only two municipalities flaring all of it.
- 54% use the methane for on-site heating (either space heating or process heating, often to heat the digester itself), reducing the use of natural gas. This is the quickest, easiest and cheapest way for a WWTP to use methane. However, in the summer there is typically little on-site need for space or process heating, so the excess gas is often flared.
- 25% co-generate heat and electricity. The heat will be used as described above. For the electricity production, some municipalities have generation contracts, selling the electricity at a fixed price to the Independent Electricity System Operator, while others are "behind-the-meter", reducing their consumption of purchased electricity.

In total, Ontario municipalities are using only a fraction of the potential biogas from their wastewater. Encouragingly, a further seventeen municipalities in the ECO's water-energy efficiency survey (see Appendix A) are looking at various options to utilize biogas from their WWTP facilities more effectively.

Table 8.1 lists the main plants that currently capture and use their biogas for co-generation of heat and electricity, based on information from the Canadian Biogas Association, supplemented by the ECO's survey and additional research.[14]

Table 8.1. Anaerobic Digesters at Ontario Wastewater Treatment Plants Used for Co-generation

Municipality	Electrical Co-generation Capacity (kilowatts)
Barrie	500
Chatham-Kent[15]	250
Collingwood[16] (in development)	65
Guelph	500
Hamilton	1600
Kingston[17]	370
Mississauga – Clarkson (in development)	1400
Ottawa	2400
Peterborough[18]	380
Thunder Bay	600
Toronto - Ashbridge's Bay (in development)	10,000
Toronto - Humber	4700
Waterloo Region (in development, three different wastewater plants – Galt, Kitchener, Waterloo)[19]	1200 (3 plants combined)

Source: Canadian Biogas Association (2013).[20]

Hamilton biogas storage sphere and co-generation equipment. Source: City of Hamilton.

Hamilton is currently unique in that in addition to co-generation, it converts some biogas into RNG and injects it into the natural gas pipeline system.[21] Some of the RNG is then used to for Hamilton's natural gas fuelled buses. Hamilton, however, does not advertise this on its buses as the bio-bus in Bristol, England did.

This GENeco Bio-Bus is powered by your waste for a sustainable future
GENeco
Tell us what
you think

Bio-bus– showing where the fuel comes from

Source: Wessex Water/Julian James Photography.

8.4 Barriers to Energy Recovery at Wastewater Treatment Plants

Why don't more Ontario wastewater plants recover energy from sewage? Three of the main barriers include:

- a burdensome environmental approvals process;
- uncertainty about financial benefits; and
- insufficient economies of scale.

Some additional barriers (not discussed in this report)[22] include lack of human resources and technical knowledge among municipal staff to manage a biogas project; a focus on compliance with sewage works approvals as the plant's core business; and, limited space on-site (e.g., London, Ontario), as AD requires more land area than incineration (although less than composting).[23] An additional barrier could be the costs associated with the conversion of old legacy aerobic digestion systems to anaerobic systems.

8.4.1 Environmental Approvals

For a municipality to install or alter an AD at its WWTP, it must apply for an amendment to the WWTP's Environmental Compliance Approval (ECA) under section 53 of the *Ontario Water Resources Act*. In addition, a municipality will either need to apply for or amend their section 9 ECA for air emissions under the *Environmental Protection Act*. This is not a decision to be taken lightly. In addition, local municipal zoning and site plan approvals will be required. Such applications involve a considerable amount of time, effort, expense and uncertainty, and expose municipalities to the possibility that the Ministry of the Environment and Climate Change (MOECC) will require changes to other elements of the ECAs. Long approvals delays are common, and can materially drive up project costs.

The approval process is even more challenging if the municipality wants to use the biogas to generate electricity (often through a combined heat and power unit). No matter how small, this requires a Renewable Energy Approval (REA) under O. Reg. 359/09 of the *Environmental Protection Act*, irrespective of whether the electricity is to be sold into the grid.[24] Appendix 1 of the technical guide to obtaining an REA provides the details of what is required to secure this approval.[25] Requirements for obtaining a REA include extensive plans and reports (e.g., noise and odour assessments; a heritage assessment) as well as public consultation. Preparing the application can take well over a year,[26] and cost a significant amount plus the municipality must pay the MOECC as much as $27,000 to review the application,[27] a considerable expense for most municipalities. Over and above this cost, are the costs for the engineering and design studies required to secure the approvals, which can be significant and be as much as $1 million.

The Climate Change Action Plan committed Ontario to establish a low-carbon content requirement for natural gas.

It is not yet clear what, if any, additional approvals would be required to supply renewable natural gas into natural gas pipelines.

8.4.2 Uncertainty about Cost Savings

Energy recovery from biogas production requires a large initial financial investment, particularly if the wastewater plant does not already have AD.

AD projects face the same issues with access to capital as energy efficiency projects (discussed in Chapter 4). Funds are scarce and there is intense competition with other possible projects, including those perceived as more closely associated with the plant's core business.[28] In this competition, energy recovery projects have been hampered by uncertainty about the future market value of, and demand for, biogas.

These issues should become clearer in the near future.

The June 2016 Climate Change Action Plan committed Ontario to establish a low-carbon content requirement for natural gas. In its September 2016 *Regulatory Framework for the Assessment of Costs of Natural Gas Utilities' Cap and Trade Activities*, the Ontario Energy Board identified RNG as a potential GHG abatement measure that gas utilities can undertake to meet their compliance obligations under cap and trade, (i.e., the *Climate Change Mitigation and Low Carbon Economy Act, 2016*). The three rate-regulated gas utilities[29] have now filed their first compliance plans under that framework. The two main gas utilities, Enbridge and Union, both indicated their intention to move toward the integration of RNG into their gas supply over the longer term but not as part of their 2017 compliance options. However, they anticipate the renewable content of natural gas from RNG development will play an increasing role in future compliance plans, and in Union's case this could be as early as 2018.[30]

In December 2016, the Minister of Energy wrote to the Ontario Energy Board:

> We intend to consider how RNG will help meet Ontario's future energy needs during the development of the next Long-Term Energy Plan… I encourage the OEB to move forward in a timely manner to include RNG as a potential fuel that could help reduce GHG emissions as a part of the gas utilities' supply portfolios.[31]

In response, the OEB announced that by the end of 2017, it will develop a new framework for the Assessment of Distributor Gas Supply Plans. The framework "will set out the OEB's expectations and approach to issues related to including RNG within the distributors' gas supply portfolios".[32] In April 2017, the OEB established a technical working group to assist with this task.

Current indications are that gas utilities are having difficulty identifying enough potential sources of biogas to meet anticipated demand, even though the OEB's Framework is likely to permit them to charge more for RNG than they do for fossil natural gas. This suggests that WWTPs should be able to sell any RNG that they can generate, at a predictable price and on long-term contracts, if they have ready access to a natural gas pipeline. In addition, there is the potential for biogas to be used for electricity generation behind the meter, particularly in cases where there is not ready access to a natural gas pipeline.

Ontario can make energy recovery cost-effective by enabling WWTPs to digest appropriate local food/organic wastes.

8.4.3 Economies of Scale

Even once there is certainty about the financial value of biogas, smaller WWTPs may not produce enough biogas to make energy recovery worthwhile. The United States Environmental Protection Agency estimates that energy recovery (at least for co-generation) is only feasible at plants that treat at least 4,000-19,000 m^3 of wastewater per day, roughly the amount generated by 10,000-50,000 households.[33] The International Energy Agency estimates a minimum of about 5,000 m^3 of wastewater per day, about 12,500 households.

Many Ontario WWTPs receive less wastewater than that. However, Ontario can facilitate its proposed diversion of organics from landfill, while making energy recovery cost-effective at more WWTPs, by enabling WWTPs to digest appropriate local food/organic wastes. In addition, these sites could also be designed to receive other biomass material, such as silvergrass or switchgrass.[34] Food waste has up to three times as much energy potential as sewage sludge on a comparable dry matter basis. Technologies can enable existing WWTP anaerobic digesters to co-digest food waste and significantly increase biogas production without a physical expansion to the AD, reducing capital cost.

Co-digestion – the digestion of wastewater sludge combined with other organics transported to the WWTP – is not currently undertaken in Ontario, but there are examples elsewhere. In 2015, a wastewater facility in Gresham, Oregon achieved net-zero energy status, in part by producing 92% of its power from on-site biogas. The high production of biogas was possible due to organic inputs, such as fats, oils and grease from local restaurants.[35]

8.4.4 Saint-Hyacinthe, Quebec - A Wastewater Plant as Biogas Hub

The vision of WWTPs as energy centres is demonstrated by the City of Saint-Hyacinthe, Quebec – the 2016 Federation of Canadian Municipalities (FCM) Sustainable Communities Award winner[36] in the waste program. This project is expected to become operational by mid-2017.

At the Saint-Hyacinthe WWTP, organic and sewage wastes are combined and converted in an anaerobic digester to high quality bio-solids and pipeline quality biogas. This biogas is first used to run municipal vehicles and to heat and cool municipal buildings (including City Hall). Any excess is then injected into the local gas grid operated by Gaz Métro. The supplemental organics come from organic waste (brown bins in Quebec) collected from 23 participating municipalities, and other local sources such as greenhouses and farms. The federal government, the Quebec government and the City each covered one-third of the costs. In using its WWTP as a local energy hub for the community, this project – a first in Quebec and one of the first in North America – may provide a useful example for smaller Ontario communities, and allow Ontario to make greater use of potential biogas resources.

Of direct importance to Ontario is that this system plans to divert 100% of the collected organic waste (25,000 tonnes/year) - waste that otherwise would have gone to landfill. The AD technology with the added organics also reduced the volume of sewage sludge going to landfill by about 50%. GHG emissions from transporting sludge to landfill were reduced by about 15% due to reduced volume of landfilled solids.

This project demonstrated the need to work together to secure the volume of organics needed to make it a viable energy option. This will be particularly important for Ontario's smaller municipalities. The involvement of businesses such as greenhouses, food stores and farms who can provide a local source of organics should be encouraged. Local farms who have ADs on site also need to be at the table to avoid potential "organic supply" conflicts.

Natural gas vehicle re-fueling station using biogas
Source: Ville de Saint-Hyacinthe.

Here in Ontario, the City of Stratford has announced a similar energy recovery project. Organic waste from both Stratford and surrounding areas will go into an existing wastewater plant anaerobic digester to generate renewable natural gas for Union Gas.[37]

On March 1, 2017, Ontario announced its Strategy for a Waste-Free Ontario: Building the Circular Economy.[38] Part of this strategy is to reduce the volume of food and organic waste going to landfill, including from the industrial, commercial, and institutional (ICI) sector as mentioned above. MOECC estimates that increasing Ontario's organic diversion rate by 10% would reduce Ontario's GHG emissions by 275 kilotonnes.[39] A ban of organics from landfill is under consideration, such as the ban that has been in place in Nova Scotia since 1998.[40]

In addition to waste reduction at the source, there are two main alternatives to landfill for organic waste:

a) compost
b) anaerobic digestion

AD of organic waste is well known. There are several examples in Ontario (e.g., Disco Road Toronto, Toronto Zoo Biogas (in development), Grimsby Biogas, Woolwich Bio-En Inc.), but Ontario's existing compost/ AD capacity falls far short of the current volume of organic waste. Most of the on-farm anaerobic digesters in Ontario also receive some food-based organic waste to blend with their agricultural inputs. If organics are banned from landfill, WWTPs could provide much needed capacity to handle organic waste (e.g., from residential food waste, or commercial sources of fats, oils, and greases). Other potential organic sources may be less obvious - Waterloo has recently announced a pilot program to collect bagged dog excrement in public places, and transport it for anaerobic digestion with other organic wastes to create biogas.[41]

> If organics are banned from landfill, WWTPs could provide much needed capacity.

However, it can be challenging to store and transport organic wastes cost-effectively and with acceptable odour levels. If the transportation is fuelled by petroleum products (e.g., diesel), the GHG reduction benefit can be partially eroded irrespective of whether the waste is going to landfill or an AD.

Quebec has already adopted a 60% organics diversion target, and plans a total ban of all organics from landfills by 2020.[42] Companies and municipalities in Quebec are therefore investigating options for managing organic waste commercially. For example, municipalities near Varennes, Quebec have invested with local industry in a joint venture to divert their organics from landfill to feed a new large scale AD currently under construction. The biogas from this digester will be sold next door to a joint venture partner – GreenField Ethanol of Quebec Inc. – to displace a portion of the large volumes of natural gas currently used to dry their wet distillers grain.

8.4.5 Garburators – A Quick Way to get Food Waste to the WWTP?

Garburators (in-sink disposal units) are designed to pulverize organics (food wastes) into a pulp that is flushed down the sanitary drain. The resulting organic-rich pulp ends up in WWTPs.

Garburators can enrich the energy content (and biogas potential) of wastewater. However, municipalities generally prefer separation of organics at source (directed towards composting or AD). Garburator pulp can clog sewers, consume water flushing the material down the drain, and increase energy and chemical usage at the WWTP to handle the increased biological oxygen demand. In cities with combined storm and sanitary sewers, an additional concern is direct discharge of the food waste to waterbodies during overflow events. For this reason, Toronto prohibits garburators in older areas with combined sewers, but allows them in newer areas with separated sewer systems. Still, garburator technology has not been widely adopted in Ontario.

Another potential energy source for AD is hauled sewage – sludge pumped from septic tanks, portable toilets and holding tanks. The MOECC has estimated that Ontario generates 1.2-1.75 million m^3 of hauled sewage annually, but the true amount may be higher.[43] While much hauled sewage is already disposed of at WWTPs, Ontario still allows land application, i.e., spreading untreated sewage on agricultural land. The MOECC is considering whether to reduce or eliminate such land application.[44] If so, hauled sewage disposal at local WWTPs may become mandatory. In 2011, the Township of Georgian Bluffs implemented an anaerobic digester in Owen Sound purpose-built for digestion and co-generation of hauled sewage.[45]

Ontario's Strategy for a Waste-Free Ontario will need to consider the wider use of AD technology in the context of the province's organic waste diversion targets. A vision of what a zero organic waste future might look like was presented at an FCM Sustainability Conference, with AD at the core:

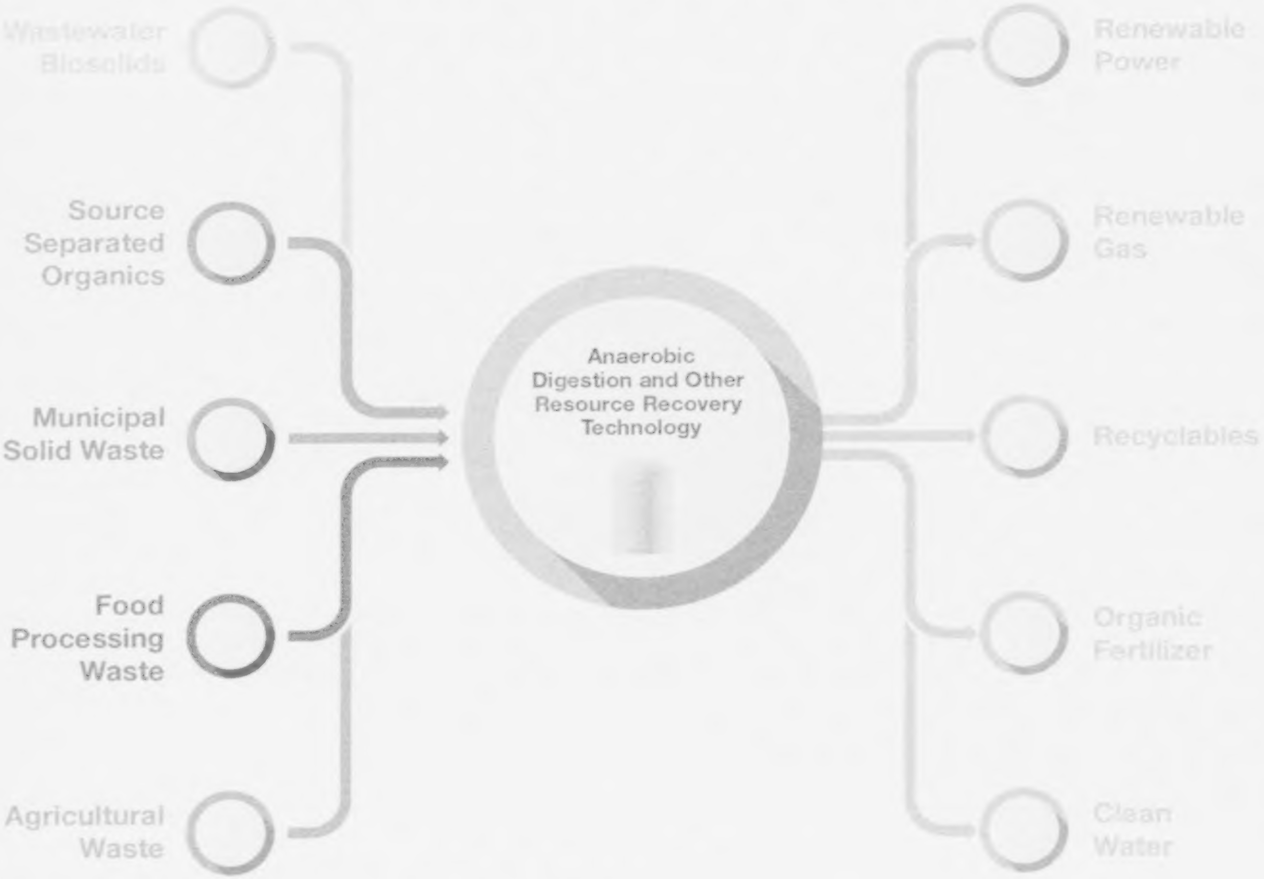


Figure 8.3. The role of anaerobic digestion in a zero-waste economy.

Source: Adapted from: Anaergia (2013).[46]

However, not all organic waste is necessarily appropriate for AD (e.g., yard waste and leaf litter are generally more suited to composting). The MOECC needs to ensure the right balance for treatment of organic waste is found, between composting facilities, on-farm biogas systems, anaerobic digesters at WWTPs and other end uses.

8.5 ECO Recommendations

To achieve GHG reduction targets, the Ontario government should help wastewater treatment sites to produce low-carbon energy from wastewater, from organics diverted from landfill, and from agricultural biomass.

Both the provincial and federal levels of government have recognized that infrastructure investments are needed in the municipal wastewater sector. Substantial funding will likely be provided through federal-provincial bilateral agreements on green infrastructure funding, including water and wastewater systems. While upgrading WWTPs to meet compliance and other operational requirements, there is a singular opportunity to also position these facilities to keep organics out of landfill and generate renewable energy. This could make these facilities a fundamental contributor to the energy profile of Ontario municipalities and help support Ontario's leadership position in the water/wastewater sector.

Recommendation: The Ministry of Infrastructure should make anaerobic digestion and energy recovery technology eligible for water/wastewater infrastructure funding.

Three specific barriers were identified:

Approvals: Given that biogas energy projects at WWTPs are built in working industrial sites, the current approvals process requiring a full REA for all projects that include electricity generation may be a lot of work for very little result in terms of environmental or natural heritage protection. The cost and effort can be prohibitive for small municipalities, relative to the amount of energy (and financial benefits) that biogas utilization can provide. A simplified approvals process has been put in place for some similar small-scale energy projects. On-farm ADs which are used to generate electricity require either an REA with simplified approval requirements, or no REA at all (although they do need to meet certain requirements under the *Nutrient Management Act, 2002*),[47] and are much more widespread in Ontario as energy production hosts than WWTPs.[48] Small-scale electricity generation from non-renewable energy sources at other facilities also follows a simpler approvals path, requiring an ECA.

The MOECC has an approvals modernization program to reduce regulatory burdens without reducing environmental protection. AD with energy recovery at WWTPs should be a candidate for a simpler, faster, more predictable approval process.

Recommendation: The Ministry of the Environment and Climate Change should, without reducing environmental protection, simplify the regulatory approvals process for energy recovery systems associated with anaerobic digestion at wastewater treatment plants, including systems that co-digest off-site organics.

The Ontario government should help wastewater treatment sites to produce low-carbon energy from wastewater, from organics diverted from landfill, and from agricultural biomass.

Financial Certainty: It appears unlikely that many more wastewater plants will make a major investment in AD and energy recovery if they must assume all the risk related to the future economic value of biogas for energy production. This is particularly the case with regards to the future economic value associated with carbon reductions. In the ECO's view, the OEB's new framework for distributor gas supply plans should set an RNG content requirement and set cost recovery criteria for the utilities. These criteria should allow gas utilities to enter into renewable gas supply contracts, for a term long enough to encourage new projects.

AD with energy recovery at WWTPs should be a candidate for a simpler, faster, more predictable approval process.

Recommendation: The Ontario Energy Board should set a renewable natural gas content requirement and cost recovery criteria for gas utilities.

Co-digestion: AD, including co-digestion at WWTPs, can play a substantial role in Ontario's plan to increase the organics diversion rate through the Strategy for a Waste-Free Ontario. At the same time, co-digestion can also allow AD with energy recovery at smaller WWTPs.

Smaller municipalities should be encouraged to work together, perhaps by collectively selecting one WWTP to host an anaerobic digester that could provide benefits to all participants. Saint-Hyacinthe, Quebec, provides an example of how such a collaborative effort could work.

In addition to organic waste diverted from landfill, there may be opportunities to utilize local, purpose-grown biomass.

It would be useful for the Ministry of the Environment and Climate Change and the Ministry of Agriculture, Food and Rural Affairs to examine the potential and the policy barriers for wastewater treatment plants to serve as "biogas hubs" using anaerobic digestion with energy recovery, including co-digestion of off-site organic material, such as material diverted from landfill and agricultural biomass.

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Appendix A

ECO 2017 Municipal Water-Energy Efficiency Survey

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A.1 Background

In early 2017, the ECO issued a survey to all Ontario municipalities (444 in total, although not all will operate municipal water or wastewater systems), examining energy use, energy efficiency initiatives, and water conservation in municipal water/wastewater operations.

110 unique municipalities responded (a 25% response rate, representing more than 70% of the provincial population served by municipal drinking water and wastewater systems). In a few cases, multiple individuals from a municipality submitted partial responses. The survey was issued online via SurveyMonkey, and supplemented ECO's more detailed meetings with selected municipalities.

A.2 Survey Responses – General Information

Questions 1 – 6 asked for general background on the municipality and the size of its drinking water system.

Q1: Which municipality are you completing the survey on behalf of?

Q2: Contact Information (name, position, e-mail address, phone number)

Q3: Please advise if you want your answers kept anonymous

Q4: What is the population of your municipality?

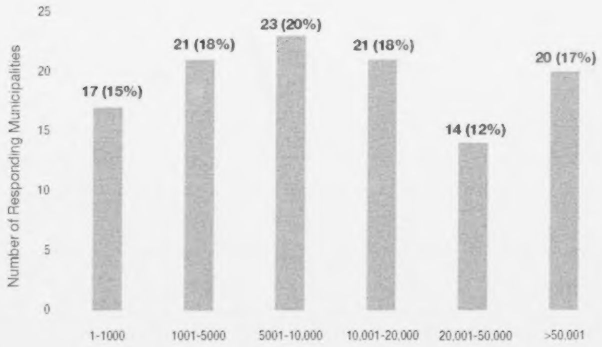

Figure A.1. "What is the population of your municipality?" (q4, 116 respondents)

Q5: What is the average daily amount of water (m^3) delivered by your drinking water system?

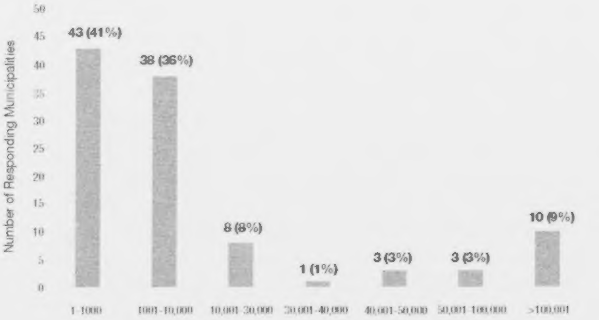

Figure A.2. "What is the average daily amount of water (m^3) delivered by your drinking water system?" (q5, 106 respondents)

Q6: What % of the municipal population does your municipal drinking water system provide service for?

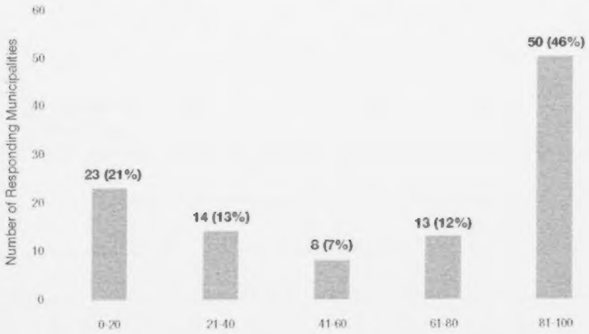

Figure A.3. "What % of the municipal population does your municipal drinking water system provide service for?" (q6, 108 respondents)

A.3 Survey Responses – Energy Conservation in Water/ Wastewater Operations

Questions 7 – 16 dealt with actions to improve energy efficiency in municipal water and wastewater operations. Included in this category were efforts to reduce the amount of water lost through leakage (and thus the energy used to treat and pump this water) within the municipal water distribution system.

Q7: Does your municipality have a plan & or strategy (stand alone or within a broader document) to reduce energy use in its water/ wastewater operations (e.g. asset management plan, energy conservation plan(s), community energy plan)?

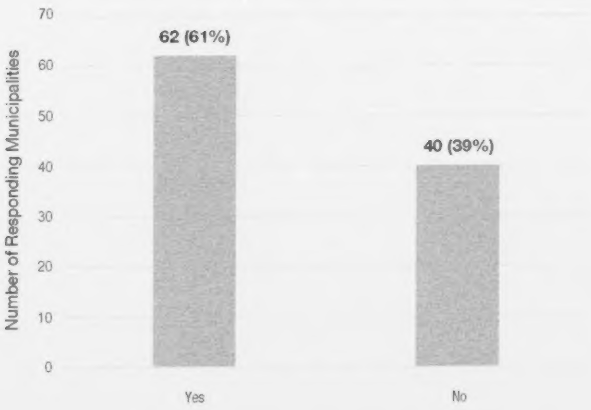

Figure A.4. "Does your municipality have a plan &/or strategy to reduce energy use in its water/ wastewater operations?" (q7, 102 respondents)

Q8: If possible, please list and provide a link to the plan(s)/strategy(s).

The type of plan most commonly noted was the five-year municipal energy conservation plan (covering the municipality as a whole, not just water/wastewater operations) required under O. Reg. 397/11 (see Chapter 3), referenced by about 15 municipalities. Ten municipalities referenced their asset management plan, although usually without a link to the plan. Three municipalities noted energy plans that were specific to water/wastewater operations. Three municipalities referenced a community energy plan. Some municipalities also used this question to describe stand-alone energy initiatives.

Q9: Are energy efficiency projects for water/ wastewater included in your municipal asset management plan?

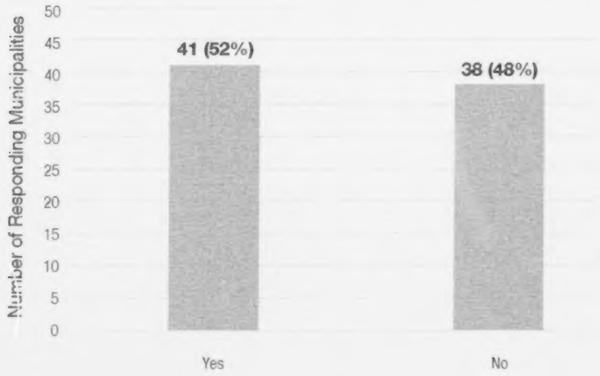

Figure A.5. "Are energy efficiency projects for water/wastewater included in your municipal asset management plan?" (q9, 79 respondents)

Q10: If "no", why not? If "yes", how are these projects evaluated and ranked against other competing projects? Please describe all criteria used.

Roughly half of responding municipalities included energy efficiency projects within their asset management plan and half did not. The most common reasons given for not including energy efficiency within asset management planning were that asset management is still too new, or too high-level in nature. Some municipalities indicated their intention to give more consideration to energy use and energy efficiency within asset management planning in future years.

Many municipalities evaluate energy efficiency projects in isolation, giving the green light to projects that will pay back quickly in energy savings (whether measured as a payback period or a return on investment). The availability of conservation program incentives and government infrastructure funding is often an influencing factor, as is the potential risk to the operation of the system.

Municipalities that do compare energy efficiency upgrades to other capital projects noted decision-making criteria such as overall cost, impact on public health and safety, prior Council commitments, and regulatory requirements.

Q11: Has your municipality participated in any energy conservation programs designed to reduce the energy use in water/wastewater operations? (e.g. electric or gas utility conservation or demand response programs, Ontario Clean Water Agency programs)

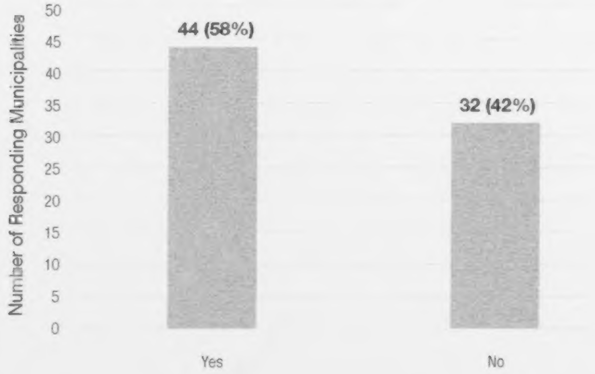

Figure A.6. "Has your municipality participated in any energy conservation programs designed to reduce the energy use of water/wastewater operations?" (q11, 76 respondents)

Q12: If "yes", what program(s), what was your experience, and do you have any suggestions for how these programs could be improved? {up to three responses permitted}

More than half of respondents had participated in an energy conservation program, although it was not always possible to determine whether this was only an informational program (e.g., an energy audit) or a program that actually implemented actions to improve energy efficiency.

Municipalities could provide up to three answers for this question, so in total, 84 different examples of participation in conservation programs were provided.

- 35 responses mentioned an electricity conservation program offered by the IESO and electric utilities. Most references were just to the saveONenergy suite of conservation programs, so the specific program could not be identified. However, most of the relevant conservation programs were named by at least one respondent (Retrofit was named by four respondents; Demand Response by three; Small Business Lighting by three; Energy Manager by two; one mention each of High Performance New Construction, Process & Systems, and Monitoring & Targeting).
- 14 responses noted conservation programs/audits delivered by the Ontario Clean Water Agency.
- 4 responses mentioned natural gas utility conservation programs, and four mentioned conversion of equipment to natural gas from a more expensive energy source.
- 2 responses mentioned the Feed-in Tariff program for renewable energy generation.
- Municipalities also used this space to describe specific conservation projects.

Almost without exception, respondents reported a positive experience with the conservation programs they had participated in. Some recommendations for improvement were to reduce the amount of paperwork, the validation requirements for smaller projects, and the wait time for incentive payments. Suggestions were also made regarding what types of projects should be eligible for incentives, clarity on why specific project proposals were approved/rejected for funding, and commitments to ensuring that funding would be available for the long-term (to allow municipalities to prioritize specific projects within the context of long-term planning).

Q13: Please provide at least one example of an energy saving technology being used in your water/wastewater operations. {up to three responses permitted}

The most common energy efficiency measures fell into four categories.

- 35 responses noted improvements to reduce energy use for water pumping. Most common was the use of variable frequency drives or "soft start" motors. Pumping optimization strategies were also mentioned.
- 25 responses noted improvements to reduce energy use for lighting at water and wastewater treatment plants, through conversion to light-emitting diodes (LEDs) and/or motion control sensors.
- 15 responses noted improvements that reduced the energy use of blowers in secondary wastewater treatment (aeration). Energy use was reduced through more efficient blowers, or through the addition of dissolved oxygen sensors that enable operators to monitor conditions and run the blowers only when necessary.
- 6 responses described using biogas from wastewater to provide useful energy (see questions 17-21).

Q14: Please provide at least one example of an energy saving technology being considered for use in your water/wastewater operations. {up to three responses permitted}

The four major categories of energy-saving measures mentioned in Q13 were also mentioned for this question. Some of the additional measures being considered include: better metering (water flow metering or energy sub-metering), improvements to the ultraviolet light disinfection process, and adjusting the timing of energy use to reduce costs. Two more innovative examples mentioned were recovering useful heat from wastewater, and installing microturbines at points within the water distribution system to generate electricity from reductions in water pressure.

Q15: What % of your municipality's water supply is estimated to be lost through leakage before reaching end users?

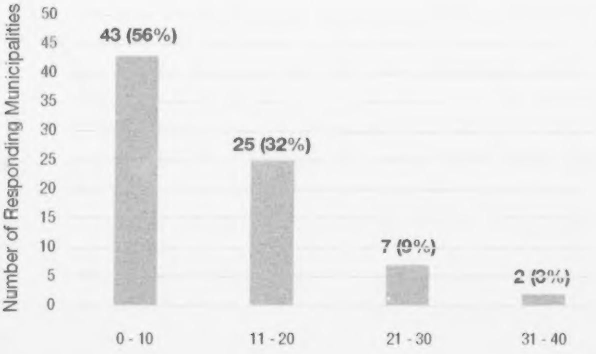

Figure A.7. "What % of your municipality's water supply is estimated to be lost through leakage before reaching end users?" (q15, 77 respondents)

Q16: What steps, if any, is your municipality taking to reduce this leakage rate?

Almost all of the 74 respondents to this question listed one or more actions being done to reduce leakage. Actions generally fell into one of the following four categories:

- Upgrades to watermain infrastructure, e.g. replacement of cast iron watermains, cement lining.
- Proactive leak detection programs, including acoustic monitoring (often annually or every two years) of pipes, and flow metering of areas within the water distribution system to detect anomalies that may indicate leaks.
- Rapid response and repair of identified leaks.
- Understanding the true rate of leakage, through universal water metering of all customers, and better accounting of unbilled water use that is not leak-related (e.g. hydrant flushing, firefighting, water used for road construction projects).

Some responses also noted steps to reduce infiltration of water into sewer pipes, and actions intended to reduce leaks on the customer side of the water meter.

A.4 Survey Responses – Energy Production From Wastewater

Questions 17 to 21 looked specifically at the experience of municipalities in making use of the energy content in wastewater (discussed in Chapter 8).

Q17: What is the average daily rate of wastewater (m³/day) treated at your wastewater treatment plant(s)?

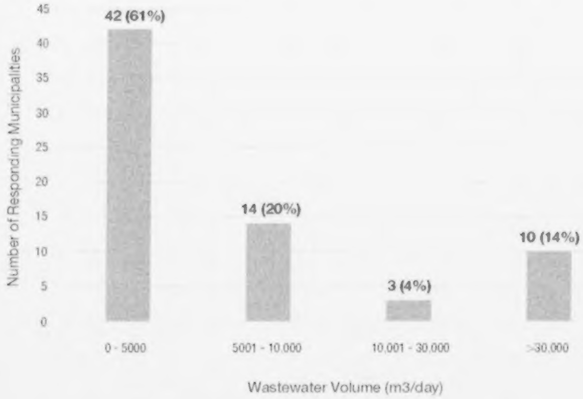

Figure A.8. "What is the average daily rate of wastewater (m³/day) treated at your wastewater treatment plant(s)?" (q17, 69 respondents)

As discussed in chapter 8, the size of a wastewater plant plays a large role in determining whether energy recovery is feasible, with the minimum volume of wastewater being in the neighbourhood of 5000 m³/day, at least for cogeneration of heat and electricity. Many survey respondents are beneath this threshold and would likely require additional organic inputs from off-site (or collaboration with other municipalities) to make energy recovery (beyond on-site heating) through anaerobic digestion viable.

Q18: Does your municipality incorporate anaerobic digestion in its wastewater treatment processes?

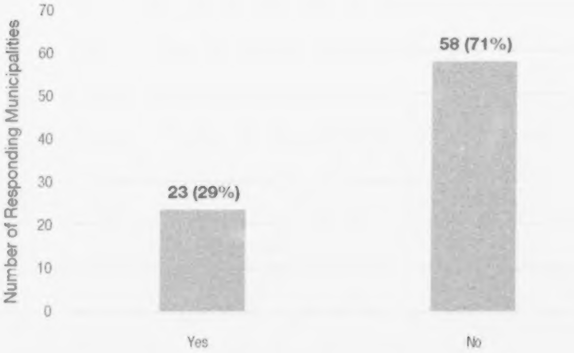

Figure A.9. "Does your municipality incorporate anaerobic digestion in its wastewater treatment processes?" (q 18, 81 respondents)

Energy recovery is only feasible for wastewater plants that have anaerobic digestion, which creates the conditions to convert more of the organic material to methane, and to capture this methane.

Q19: If "yes", how does your municipality deal with the methane generated? (check all that apply): flare; burn for on-site heat; cogenerate heat and electricity, other (please specify)

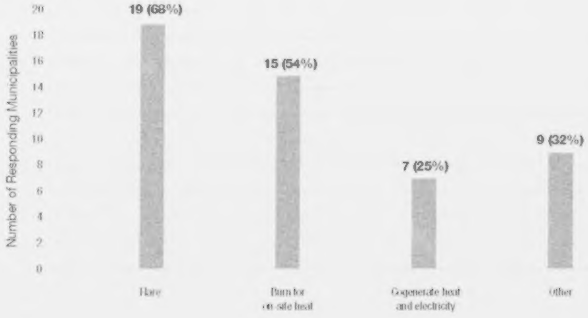

Figure A.10. "How does your municipality deal with the methane generated from the anaerobic digester?" (q19, 28 respondents)

The majority of municipalities with anaerobic digestion flare some of their gas and use some for on-site heating (only two municipalities indicated that they flare all of their gas). Some small wastewater plants (5000 m^3 or less) are making use of anaerobic digestion and using the biogas for on-site heating. Seven larger municipalities cogenerate heat and power (the smallest plant in this category processed approximately 13,000 m^3 of wastewater per day). Responses in the "other" category were generally clarifications or errors. The only additional use for methane identified by survey respondents was injection into the gas grid.

Q20: Is your municipality considering opportunities to better utilize biogas from wastewater for energy production?

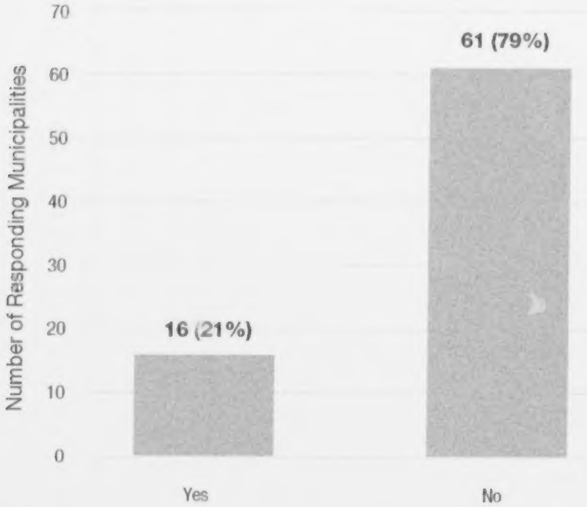

Figure A.11. "Is your municipality considering opportunities to better utilize biogas from wastewater for energy production?" (q20, 77 respondents)

Q21: If "yes", please describe.

Sixteen municipalities indicated an interest in further utilizing biogas, with eight specifically mentioning cogeneration of heat and electricity as a possibility. One noted the possibility of centralizing biosolids treatment from multiple wastewater plants to enable co-generation. Six made reference to a general review of opportunities to derive value from biogas production (e.g. comparing options such as co-generation versus injection into the gas grid).

A.5 Survey Responses – Water Conservation

Questions 22 to 26 dealt with municipal efforts regarding water conservation, both within municipal operations and in the broader community.

Q22: Does your municipality have a plan(s) to reduce water use by the municipal corporation and/or the community? (either a stand-alone plan, or as part of another document)

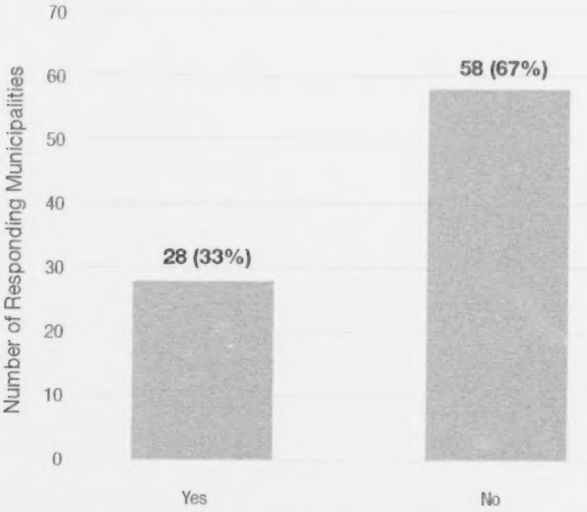

Figure A.12. "Does your municipality have a plan(s) to reduce water use by the municipal corporation and/or the community?" (q22, 86 respondents)

A

Q 23: If "yes", please list and provide a link to the plan(s).

Of the one-third of responding municipalities that indicated they have a plan to reduce water use, about a dozen referenced a comprehensive water conservation and efficiency plan or strategy containing multiple initiatives. Other responses provided here described specific actions such as installation of water meters, water-efficient fixtures in municipal buildings, public education efforts, incentives for efficient toilets and showerheads, and water restriction bylaws (see also question 25).

Q24: If "yes", does this plan cover (select all that apply): corporate water use and conservation; community water use and conservation; not applicable

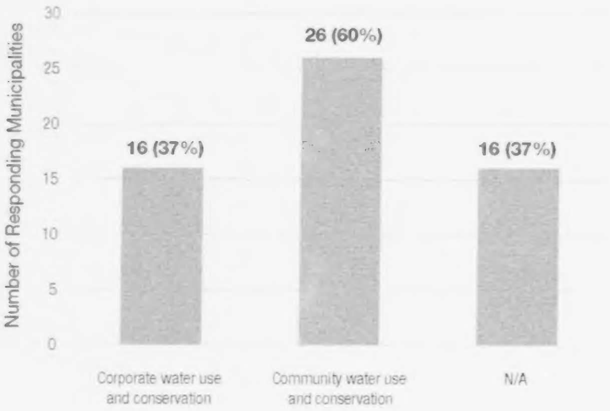

Figure A.13. "If 'yes', {what} does this plan cover?" (q24, 43 respondents)

Q25: Does your municipality offer any water conservation programs for end users?

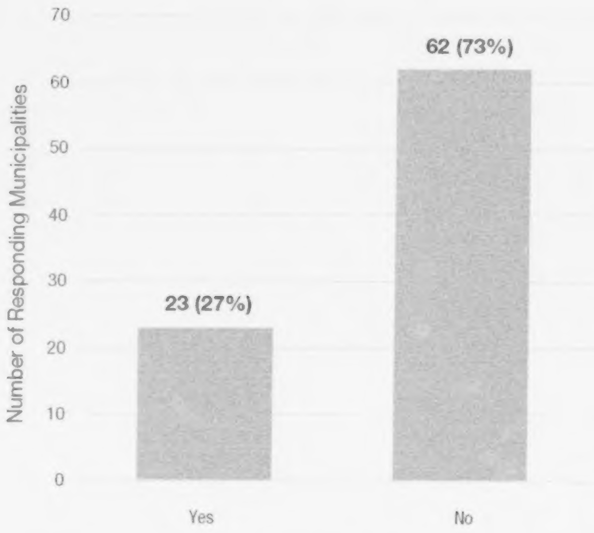

Figure A.14. "Does your municipality offer any water conservation programs for end users?" (q25, 85 respondents)

Q26: If "yes", please describe the programs offered.

About one-quarter of responding municipalities offered at least one water conservation program, with the most popular being:

- incentives for water-efficient fixtures including toilets (seven respondents);
- water metering (six respondents);
- rain barrel programs (five respondents);
- water rates to encourage conservation (three respondents); and,
- capacity buy-back programs for larger industrial, commercial and institutional customers (three respondents).

A.6 Survey Responses – Potential Actions by the Ontario Government

The final two questions in the survey asked about potential actions the provincial government could take to assist municipalities in promoting energy efficiency in water/wastewater operations and water conservation.

Q27: Which of the following actions by the Ontario government would be of {most} value to your municipality? (check all that apply):

- ***financial/informational assistance to understand the energy use of your water/wastewater operations and how it compares to other similar municipalities;***
- ***financial/informational assistance to identify opportunities to reduce energy use (e.g. energy audits, submetering energy use of equipment, etc.);***
- ***financial assistance in implementing projects that would improve the energy efficiency of water/wastewater operations (to complement incentives already available from utilities);***
- ***policy guidance/financial incentives to encourage energy production from wastewater;***
- ***flexibility in meeting point-source effluent regulations;***
- ***financial, technical, or informational assistance to implement water conservation programs for end users;***
- ***stricter water efficiency requirements in the Building Code and/or product standards;***
- ***clearer provincial guidance on rules for water reuse (e.g. greywater, partially treated wastewater).***

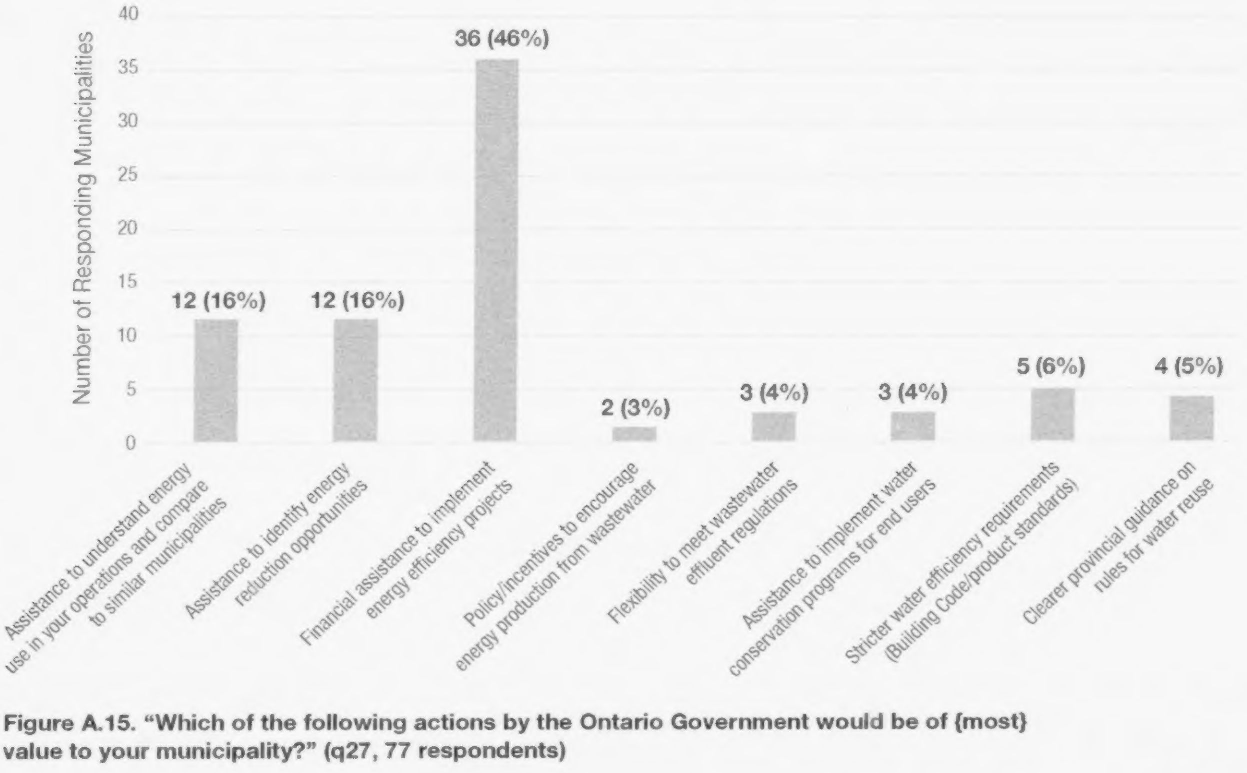

Figure A.15. "Which of the following actions by the Ontario Government would be of {most} value to your municipality?" (q27, 77 respondents)

There was a technical error in the survey functionality for this question. While the question was intended to allow respondents to check all actions that would be of value, respondents were only able to check one of the options. Therefore, the results should be interpreted as recording the action that would be of most value, from the municipality's point-of-view. Each of the eight potential actions was selected by at least two municipalities.

Not surprisingly, financial assistance to implement energy efficiency projects was the most popular choice, and was the choice of nearly half of municipalities (see Chapter 4 for a discussion of financial barriers to investments in energy efficiency). Informational assistance, both to understand and benchmark energy use, or to identify potential energy saving opportunities, was also popular, selected by almost one-third of responding municipalities. These topics are addressed in Chapter 3.

Q28: Provide any additional information relevant to items ranked in question 27 (e.g., specific recommendations, detail as to why these actions would benefit your municipality).

Most respondents used this space to indicate additional items that would be of interest to them. A few new ideas were proposed, including assistance addressing potential rate increases due to water conservation, guaranteed long-term rates of return for renewable energy projects, and outreach to the public on the benefits of water conservation.

{End of Survey}

A.7 Participating Municipalities

Admaston – Bromley, Alfred and Plantagenet, Alnnwick – Haldimand, Armstrong, Arnprior, Bayham, Belleville, Black River – Matheson, Bonnechere Valley, Bradford/ West Gwillimbury, Bruce Mines, Calvin, Carleton Place, Casselman, Central Elgin, Central Frontenac, Central Huron, Centre Hastings, Centre Wellington, Chatham – Kent, Clarence – Rockland, Clearview, Collingwood, Durham, Dysart et al, Edwardsburgh/ Cardinal, Enniskillen, Erin, Gananoque, Georgian Bluffs, Gillies, Grimsby, Guelph, Halton, Hamilton, Hanover, Hearst, Ignace, Joly, Kenora, Killoe, Hagarty and Richards, Kingston, Kingsville, Kitchener, Laird, Lincoln, London, Machin, Madawaska Valley, Manitouwadge, Markham, Matheson, Mattawa, Mississippi Mills, Mono, Muskoka, Newbury, Nipigon, Norfolk, North Dundas, North Frontenac, North Grenville, North Perth, North Shore, Oakville, Oil Springs, Orangeville, Orillia, Oxford, Peel, Pelee, Pembroke, Penetanguishene, Perth, Perth East, Perth South, Petawawa, Pickle Lake, Point Edward, Port Hope, Red Rock, Renfrew, Ryerson, Sables-Spanish Rivers, Sault Ste. Marie, Selwyn, Shelburne, Sioux Lookout, South Algonquin, South Huron, Southwold, St. Catharines, St. Charles, St. Mary's, Stratford, Strathroy – Caradoc, Tay, Tecumseh, Thorold, Thunder Bay, Timmins, Toronto, Val Rita, Wasaga Beach, Welland, West Grey, Westport, White River, Windsor, York.

Glossary

Aeration: adding air to wastewater to facilitate biological decomposition of organic matter.

Aerobic/anaerobic digestion: biological treatment of sewage sludge to reduce odours, destroy pathogens, and reduce sludge volume. Can be done in the presence (aerobic) or absence (anaerobic) of air.

Algal bloom: excessive growth of algae in freshwater or marine water systems.

Asset management planning: "the process of making the best possible decisions regarding the building, operating, maintaining, renewing, replacing and disposing of infrastructure assets. The objective is to maximize benefits, manage risk, and provide satisfactory levels of service to the public in a sustainable manner." (Ontario Ministry of Infrastructure)

Biogas: a mixture of gases (mostly methane and carbon dioxide) produced by the anaerobic digestion of organic matter, which can be used for energy production. Can be produced from feedstocks such as agricultural waste, manure, municipal waste, sewage, or food waste.

Broader public sector: usually includes municipalities, academic institutions (colleges and universities), school boards, and hospitals.

Co-digestion: combined digestion of different types of organics, such as sewage sludge and food waste.

Co-generation: the simultaneous production of electricity and heat from the same energy source.

Effluent: outflow of water, usually referring to wastewater (treated or untreated) discharged into a water body.

Energy intensity: the amount of energy required for one unit of a specified process or characteristic (e.g., the amount of energy needed to treat one litre of water, or to heat one square metre of building space). Enables comparisons of relative energy use.

Equivalent: used to aggregate energy use from different energy sources into a common comparative unit, e.g., "equivalent kilowatt-hours" converts energy use from multiple energy sources into kilowatt-hours of electricity.

Global adjustment: charge paid by electricity customers in Ontario, for costs of operating the electricity system that are not recovered through the market price.

Greywater: the relatively clean wastewater from bathroom sinks, showers and tubs, and washing machines.

Load shifting: adjusting the timing (not the overall amount) of electricity use, often to take advantage of lower electricity rates at certain times of day.

Portfolio Manager: software tool to measure, track and benchmark facility-level energy and water consumption, and greenhouse gas emissions.

Potable water: water that is safe to drink or to use in food preparation.

Rainwater harvesting/capture: rainwater collection in rain barrels or cisterns at the home or commercial/industrial facility and use of that water on-site.

Reverse osmosis: a water purification technology that uses a semipermeable membrane to remove ions, molecules, and larger particles.

Sludge: semi-solid mass separated out of wastewater. "Treated sludge" or "biosolids" are terms that refer to sludge that has undergone additional treatment, such as digestion and dewatering.

Stormwater: water from rain or snow events. Stormwater runoff may absorb into soil, drain into nearby water bodies or collect in stormwater drains. In older systems, stormwater may flow into the sanitary sewer network and to the wastewater treatment plant; in newer systems it is usually collected in a separate network and not treated.

Water reuse: using water more than once between its removal from, and return to, the natural environment (often with some form of treatment after initial use). Can be decentralized (reused on-site by customer instead of going into sewer system), or centralized (collected through sewer system, treated centrally, and reused).

Water taking/withdrawal: extraction of water from a source (surface water or groundwater) in the natural environment.

Water treatment: removing contaminants from water to bring it up to drinking water quality standards.

Wastewater treatment: the clean-up of wastewater (material discharged into and transported through the sanitary sewer system) to applicable standards before return to the natural environment or other use (see 'water reuse').

List of abbreviations

AD: anaerobic digestion

AMO: Association of Municipalities of Ontario

AMP: asset management planning

BPS: broader public sector

CH_4: chemical symbol for methane

CHP: combined heat and power

CO_2eq: carbon dioxide equivalent

Co-gen: cogeneration system

EA: Environmental Assessment

ECA: Environmental Compliance Approval

ECCC: Environment and Climate Change Canada

ECO: Environmental Commissioner of Ontario

eGWh: equivalent gigawatt-hour

ekWh: equivalent kilowatt-hour

FCM: Federation of Canadian Municipalities

FIT: Feed-in Tariff

GHG: greenhouse gas

GJ: gigajoule

GWh: gigawatt-hour

ICI: industrial, commercial, and institutional

IESO: Independent Electricity System Operator

IPCC: Intergovernmental Panel on Climate Change

kW: kilowatt

LCA: life cycle assessment

lpf: litres per flush

m^3: cubic meters

mg/l: milligrams per litre

MJ: megajoule

ML: megalitre

MMA: Ministry of Municipal Affairs

MOECC: Ministry of the Environment and Climate Change

MOI: Ministry of Infrastructure

Mt: megatonne

MURB: multi-unit residential building

MW: megawatt

NIR: National Inventory Report

OBC: Ontario Building Code

OCWA: Ontario Clean Water Agency

OEB: Ontario Energy Board

OMAFRA: Ontario Ministry of Agriculture, Food and Rural Affairs

OWWA: Ontario Water Works Association

REA: Renewable Energy Approval

RNG: renewable natural gas

ROI: return on investment

SCADA: supervisory control and data acquisition

SNCA: South Nation Conservation Authority

SWI: Showcasing Water Innovation

TJ: terajoule

TOO: Transmission Operations Optimizer

UV: ultra-violet

US EPA: United States Environmental Protection Agency

WWTP: wastewater treatment plant

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Environmental
Commissioner
of Ontario

1075 Bay Street, Suite 605, Toronto, Ontario M5S 2B1
Tel: 416-325-3377 Fax: 416-325-3370 1-800-701-6454
www.eco.on.ca

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